AL.2.1993-227
C.2.

REPORT #
RRTAC 92-6

CANADIANA

JUL 27 1993

Alberta Drilling Waste Sump Chemistry Study

Volume I: Report

Heritage Fund

Alberta
LAND CONSERVATION AND
RECLAMATION COUNCIL
Reclamation Research
Technical Advisory Committee

Alberta's Reclamation Research Program

Regulating surface disturbances in Alberta is the responsibility of the Land Conservation and Reclamation Council. The Council Chairman is from Alberta Environmental Protection. The Council oversees a reclamation research program, established in 1978, to identify the most efficient methods for achieving acceptable reclamation in the province. Funding for the research program is provided by Alberta's Heritage Savings Trust Fund, Land Reclamation Program.

To assist with the development and administration of the research program, the Council appointed the inter-departmental Reclamation Research Technical Advisory Committee (RRTAC). The Committee consists of eight members representing the Alberta Departments of Agriculture and Rural Development, Energy, and Environmental Protection, and the Alberta Research Council. The Committee updates research priorities, reviews research proposals, organizes workshops, and otherwise acts as the coordinating body for reclamation research in Alberta.

Additional information on the Reclamation Research Program may be obtained by contacting:

Chris Powter, Chairman
Reclamation Research Technical Advisory Committee
Alberta Environmental Protection
3rd Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta T5K 2J6
(403) 427-4147

Additional copies of this report may be obtained at a cost of $10.00 plus GST from:

Publication Services
Queen's Printers
11510 Kingsway Avenue
Edmonton, Alberta T5G 2Y5
(403) 427-4952

Prices quoted in the Reclamation Research Reports section of this Report do not include G.S.T. Please make cheques payable to The Provincial Treasurer.

This report may be cited as:

Macyk, T.M., S.A. Abboud and F.I. Nikiforuk, 1992. Alberta Drilling Waste Sump Chemistry Study Volume I: Report. Alberta Land Conservation and Reclamation Council Report No. RRTAC 92-6. ISBN 0-7732-0879-8. 217 pp. **NOTE: Volume II: Appendices is only available from the Alberta Research Council.**

REPORT #
RRTAC 92-6

Alberta Drilling Waste Sump Chemistry Study

Volume I: Report*

by

T.M. Macyk, S.A. Abboud and F.I. Nikiforuk

Alberta Research Council

Prepared for

The Oil and Gas Reclamation Research Program

ALBERTA LAND CONSERVATION AND RECLAMATION COUNCIL
(Reclamation Research Technical Advisory Committee)

and

The Drilling Waste Review Committee

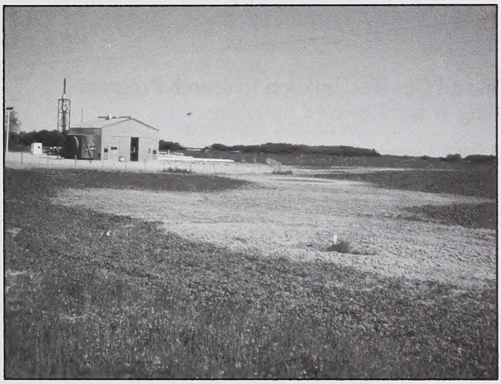
* Volume II: Appendices is only available through the Alberta Research Council

1992

Digitized by the Internet Archive
in 2015

https://archive.org/details/albertadrillingw01macy

Oil and Gas Reclamation Research Program



Members: Chris Powter (Chairman) - Alberta Environmental Protection; Roger Creasy - Energy Resources Conservation Board; Emil Dombroski - Alberta Environmental Centre; Al Fedkenheuer - NOVA Corporation of Alberta; Jim Fujikawa - Alberta Environmental Protection; Arnold Janz - Alberta Environmental Protection; Alan Kennedy - Imperial Oil; Leon Marciak - Alberta Agriculture and Rural Development; Doug Mead - Shell Canada Resources Limited; Sam Takyi - Alberta Environmental Protection; Wayne Tedder - Alberta Environmental Protection; Bill Wolff - Bisset Resource Consultants.

DISCLAIMER

This report is intended to provide government and industry staff with up-to-date technical information to assist in the preparation and review of Development and Reclamation Approvals, and development of guidelines and operating procedures. This report is also available to the public so that interested individuals similarly have access to the most current information on land reclamation topics.

The opinions, findings, conclusions, and recommendations expressed in this report are those of the authors and do not necessarily reflect the views of government or industry. Mention of trade names or commercial products does not constitute endorsement, or recommendation for use, by government or industry.

Throughout the report numerical values are used to help organize and compare the data. **These values were selected for the purposes of this report only and are not intended as regulatory values.**

REVIEWS

This report was reviewed by members of the Oil and Gas Reclamation Research Program Committee, RRTAC and the government/industry Drilling Waste Review Committee.

FUNDING

Funding for this work was provided by the Alberta Heritage Savings Trust Fund, Land Reclamation Program through the Alberta Land Conservation and Reclamation Council. The oil and gas industry provided approximately $585,000 towards the sampling and analyses of the drilling wastes. The contribution of the industry is greatly appreciated by RRTAC.

TABLE OF CONTENTS

Page

LIST OF TABLES v

LIST OF FIGURES xi

EXECUTIVE SUMMARY xii

ACKNOWLEDGEMENTS xiv

1. INTRODUCTION 1

2. OBJECTIVE 2

3. MATERIALS AND METHODS 3
3.1 Organization and Funding 3
3.2 Sampling 3
3.2.1 Sampling Logistics 3
3.2.2 Sump Selection 3
3.2.3 Sampling Protocol 4
3.2.3.1 Liquid Phase Sampling 4
3.2.3.2 Solid Phase Sampling 6
3.2.3.3 Sampling Tools 8
3.2.3.4 Safety Equipment 8
3.2.3.5 Field Problems Encountered 9
3.3 Analytical Procedures 9
3.3.1 Liquid Phase Samples (ARC Laboratory) 9
3.3.2 Liquid Phase Samples (ERCB Laboratory) 10
3.3.3 Solid Phase Samples (ARC Laboratory) 10
3.3.4 Solid Phase Samples (ERCB Laboratory) 12

4. RESULTS AND DISCUSSION 13
4.1 Sampling Summary 13
4.2 Sump Location/Sample Distribution 15
4.3 Well Depth and Mud Volume 15
4.4 Analytical Results 19
4.4.1 Liquid Phase Data 20
4.4.1.1 All Liquid Phase Data 20
4.4.1.2 Comparison of Waste Types and Regions 27
4.4.2 Solid Phase Data 27
4.4.2.1 Chemical and Physical Properties 27
4.4.2.2 Saturated Paste Extract Properties 31
4.4.2.3 DTPA Extractable Elements 31
4.4.2.4 Total Elemental Analysis Data 35

continued ...

TABLE OF CONTENTS (continued)

Page

4.5 DATA INTERPRETATION FOR LAND APPLICATION OF SOLID PHASE WASTES . 40
4.5.1 Calculations 40
4.5.1.1 Scenario 1 44
4.5.1.2 Scenario 2 44
4.5.1.3 Scenario 3 45
4.5.1.4 Scenario 4 46

4.6 DATA INTERPRETATION FOR LAND APPLICATION OF LIQUID PHASE WASTES 49
4.6.1 Calculations 49

4.7 LAND APPLICATION OF SOLID AND LIQUID PHASE WASTES COMBINED 52
4.7.1 Calculations 52

5. SUMMARY 55
5.1 Sampling 55
5.2 Well Depth and Mud Volume 55
5.3 Analytical Results 55
5.3.1 Liquid Phase Data 55
5.3.2 Solid Phase Data 56
5.3.2.1 Chemical and Physical Properties 56
5.3.2.2 Saturated Paste Extract Properties 56
5.3.2.4 Total Elemental Analysis Data 56

5.4 DATA INTERPRETATION 56
5.4.1 Solid Phase Wastes 56
5.4.2 Liquid Phase Wastes 57
5.4.3 Solid and Liquid Phase Wastes Combined 57

6. CONCLUSIONS 58

7. REFERENCES 59

APPENDIX 1. LIST OF SAMPLING CONTACTS 61

APPENDIX 2. WELL DEPTHS AND MUD VOLUMES 64

APPENDIX 3. STATISTICAL PARAMETERS FOR THE PROPERTIES OF THE LIQUID PHASE SAMPLES 72

continued ...

TABLE OF CONTENTS (continued)

Page

APPENDIX 4: STATISTICAL PARAMETERS FOR EC, CL, AL, CR, FE, AND OIL CONTENT IN THE FRESHWATER GEL LIQUID PHASE SAMPLES FOR THE DIFFERENT ERCB REGIONS 83

APPENDIX 5: STATISTICAL PARAMETERS FOR THE CHEMICAL AND PHYSICAL PROPERTIES OF THE SOLID PHASE SAMPLES. 86

APPENDIX 6: STATISTICAL PARAMETERS OF THE SATURATED PASTE EXTRACT DATA FOR THE SOLID PHASE SAMPLES 92

APPENDIX 7: STATISTICAL PARAMETERS FOR EC IN THE SOLID PHASE WASTE TYPES FOR THE DIFFERENT ERCB REGIONS 98

APPENDIX 8: STATISTICAL PARAMETERS FOR CL IN THE SOLID PHASE WASTE TYPES FOR THE DIFFERENT ERCB REGIONS 101

APPENDIX 9: STATISTICAL PARAMETERS FOR SAR IN THE SOLID PHASE WASTE TYPES FOR THE DIFFERENT ERCB REGIONS 104

APPENDIX 10: STATISTICAL PARAMETERS OF THE DTPA-NH4HCO3 EXTRACT DATA FOR THE SOLID PHASE SAMPLES 107

APPENDIX 11: STATISTICAL PARAMETERS OF THE TOTAL ELEMENTAL ANALYSIS DATA FOR THE SOLID PHASE SAMPLES. 113

APPENDIX 12: STATISTICAL PARAMETERS FOR TOTAL ELEMENTAL CU IN THE SOLID PHASE WASTE TYPES FOR THE DIFFERENT ERCB REGIONS 119

APPENDIX 13: STATISTICAL PARAMETERS FOR TOTAL ELEMENTAL CR IN THE SOLID PHASE WASTE TYPES FOR THE DIFFERENT ERCB REGIONS 122

APPENDIX 14: STATISTICAL PARAMETERS FOR TOTAL ELEMENTAL NI IN THE SOLID PHASE WASTE TYPES FOR THE DIFFERENT ERCB REGIONS 125

APPENDIX 15: STATISTICAL PARAMETERS FOR TOTAL ELEMENTAL ZN IN THE SOLID PHASE WASTE TYPES FOR THE DIFFERENT ERCB REGIONS 128

APPENDIX 16: MEAN VALUES FOR SELECTED PROPERTIES OF THE DRILLING WASTE SOLID SAMPLES. 131

APPENDIX 17: APPLICATION RATES FOR THE DRILLING WASTE SOLIDS (SCENARIO 4). 138

continued ...

TABLE OF CONTENTS (concluded)

Page

APPENDIX 18: AREAS REQUIRED FOR LAND APPLICATION OF THE DRILLING WASTE SOLIDS (SCENARIO 4). 145

APPENDIX 19: LIMITING ANALYTES REQUIRING >1 HA AREA FOR LAND APPLICATION OF DRILLING WASTE SOLIDS (SCENARIO 4). 152

APPENDIX 20: THICKNESS OF THE DRILLING WASTE SOLIDS LAYER APPLIED TO LAND (SCENARIO 4). 156

APPENDIX 21: MEAN VALUES FOR SELECTED PROPERTIES OF THE DRILLING WASTE LIQUIDS. 163

APPENDIX 22: APPLICATION RATES FOR THE LIQUID PHASE DRILLING WASTES. 170

APPENDIX 23: AREA REQUIRED FOR LAND APPLICATION OF THE LIQUID PHASE DRILLING WASTES. 176

APPENDIX 24: LIMITING ANALYTES REQUIRING >1 HA AREA FOR LAND APPLICATION OF THE LIQUID PHASE DRILLING WASTES. 180

APPENDIX 25: THICKNESS OF THE LIQUID PHASE DRILLING WASTE LAYER APPLIED. 184

APPENDIX 26: POTENTIAL APPLICATION RATES FOR THE SOLID AND LIQUID WASTES. 190

APPENDIX 27: AREA REQUIRED FOR THE LAND APPLICATION OF THE SOLID AND LIQUID WASTES. 196

APPENDIX 28: LIMITING ANALYTES REQUIRING >1 HA FOR APPLICATION OF THE SOLID AND LIQUID WASTES. 200

VOLUME II: APPENDICES 29 to 33

LIST OF TABLES

Page

Table

1. Number of Sumps Sampled Relative to Waste Type and ERCB Region 16
2. Statistical Parameters for Well Depths and Mud Volumes (all locations) 17
3. Well Depths Relative to Sumps Sampled 17
4. Distribution of Sumps Sampled by Well Depth and Waste Type 17
5. Well Depths Relative to Location (Meridian) 18
6. Mud Volume Relative to Sumps Sampled 18
7. Distribution of Sumps Sampled by Mud Volume and Waste Type 18
8. Mud Volumes Relative to Well Location (Meridian) 19
9. Statistical Parameters of the Liquid Phase Samples 21
10. Maximum Acceptable Concentrations (mg/L) of Various Constituents in Canadian Waters 22
11. Maximum Potential Acceptable Levels of Selected Parameters in Liquid Phase Drilling Wastes 23
12. Listing of Sumps (Samples) That Exceed Potential Maximum Acceptable Limits for Specific Criteria 24
13. Statistical Parameters for EC (dS/m) in the Different Liquid Phase Waste Types 28
14. Statistical Parameters for Cl (mg/L) in the Different Liquid Phase Waste Types 28
15. Statistical Parameters for Al (mg/L) in the Different Liquid Phase Waste Types 28
16. Statistical Parameters for Cr (mg/L) in the Different Liquid Phase Waste Types 29
17. Statistical Parameters for Fe (mg/L) in the Different Liquid Phase Waste Types 29
18. Statistical Parameters for Oil Content (mg/L) in the Different Liquid Phase Types 29

continued ...

List of Tables (Concluded)

Page

19. Statistical Parameters of the Chemical and Physical Properties for the Solid Phase Sample 30

20. Statistical Parameters of the Saturated Paste Extract Data for the Solid Phase Samples 32

21. Statistical Parameters for Saturated Paste EC (dS/m) in the Different Solid Phase Waste Types 33

22. Statistical Parameters for Saturated Paste Cl (mg/L) in the Different Solid Phase Waste Types 33

23. Statistical Parameters for Saturated Paste SAR in the Different Solid Phase Waste Types 33

24. Statistical Parameters of the DTPA-NH_4HCO_3 Extract Data for the Solid Phase Samples 34

25. Statistical Parameters of the Total Elemental Analysis Data for the Solid Phase Samples 36

26. Elemental Constituents of Soils 37

27. Statistical Parameters for Total Elemental Cu (ug/g) in the Different Solid Phase Waste Types 38

28. Statistical Parameters for Total Elemental Cr (ug/g) in the Different Solid Phase Waste Types 38

29. Statistical Parameters for Total Elemental Ni (ug/g) in the Different Solid Phase Waste Types........... 38

30. Statistical Parameters for Total Elemental Zn (ug/g) in the Different Solid Phase Waste Types 39

31. Glossary of Terms Used in the Calculation of Waste Application Rates and Areas Required for Disposal 41

32. Limits for the Land Application of Various Analytes 42

33. Summary of Limiting Parameters for Sumps Requiring >1 ha for Disposal of Solid Wastes 50

34. Number of Sumps with Limiting Analytes Requiring >1 ha Area for Land Application of Solid Wastes Relative to Waste Type 51

35. Summary of Limiting Parameters for Sumps Requiring >1 ha for Disposal of Liquid Wastes 53

36. Summary of Limiting Parameters for Sumps Requiring >1 ha for Disposal of Liquid and Solid Wastes Combined for Each Sump 54

LIST OF FIGURES

Page

Figure

1. ARC - Sump Sampling Site Description 5

2. Sample Description 7

3. Location of Sump Sampling Sites 14

4. Measured vs Calculated EC for Three Pot Trial Soils 47

5. Measured vs Calculated SAR for Three Pot Trial Soils 48

EXECUTIVE SUMMARY

In 1990, a study was undertaken to characterize drilling wastes from throughout Alberta. The data provided a basis for updating the existing Energy Resources Conservation Board (ERCB) (1975) guidelines/criteria for disposal of these wastes in the province. Updating of the existing guidelines/criteria is being completed by the joint government and industry Drilling Waste Review Committee (DWRC) struck in 1987.

The subobjectives of the study included:

1. sampling of representative sumps from throughout Alberta;
2. characterization of the drilling wastes by completing pertinent analyses;
3. data management and synthesis; and,
4. report preparation.

The study design was completed by the Alberta Research Council (ARC) (Macyk and Abboud 1990) with funding from the Reclamation Research Technical Advisory Committee (RRTAC). Funding for the sample collection and analyses was provided by the Canadian Petroleum Association (CPA), Independent Petroleum Association of Canada (IPAC), and Small Explorers and Producers Association of Canada (SEPAC).

The ARC was the overall manager of the sampling program with a coordinator and two three-man sampling crews from Nor-Chief Consulting Services (1978) Ltd. of Calgary. All sampling, sample handling and transport were conducted in accordance with the study design specifications. The sampling program began June 5, 1990 and concluded on October 19, 1990. Approximately 50% of the sites sampled represented sumps resulting from the previous winter drilling program with the remainder representing sampling shortly after rig release. The sampling program involved the collection from 128 individual sumps or physical structures at 114 different geographic locations. These included 72 freshwater gel, 19 invert, 27 KCl, 2 NaCl and 8 Other waste type sumps. A total of 288 liquid phase, 653 solid phase, 9 QA/QC and 30 source water samples were obtained.

Well depth information relative to most of the sumps sampled was provided by the respective companies and the ERCB. Mud volume was estimated from measurements taken by the field crews. The data indicated that 23% of the wells had depths equal to or less than 1000 m, 33% had depths greater than 1000 m and less than or equal to 2000 m and 32% had depths greater than 2000 m, and less than or equal to 3000 m. The deepest wells drilled occurred west of the 5th Meridian.

The data indicated that 75% of the sumps sampled had a mud volume less than or equal to 1000 m^3 or about 6000 barrels. The largest mud volumes generally occurred at well locations west of the 6th Meridian.

The analytical work was completed according to the study design of Macyk and Abboud (1990). Statistical analysis was undertaken to summarize the data in a systematic manner.

Two approaches were taken to synthesize or reduce the volume of data that was generated. First, comparisons of values for selected parameters or analytes relative to waste type and/or ERCB region were made.

Secondly, values for selected parameters or analytes were compared to existing water or soil quality guidelines.

The liquid phase data were compared to guidelines for irrigation water quality prepared by the Task Force on Water Quality Guidelines of the Canadian Council of Resource and Environment Ministers (CCREM 1987). In completing this comparison it became apparent that the parameters which warranted attention were electrical conductivity (EC), Cl, Cr, Fe, B, and oil content. A listing of the specific sumps and the respective samples that had values exceeding the potential maximum acceptable limits was prepared. A series of tables was generated to compare the specific parameters between waste type and between regions for a given waste type.

The solid phase samples were analysed for several chemical and physical properties, soluble ions in saturated paste extracts, plant available trace elements (DTPA extractable), and total elemental content. The mean values based on all samples were: pH (H_2O) - 8.72; total carbon (TC) - 4.5%; $CaCO_3$ equivalent - 9.89%; acid neutralizing capacity (ANC) - 15.59%; and oil content - 1.28%.

Statistical parameters relative to the saturated paste extract properties were provided and EC, Cl, and sodium adsorption ratio (SAR) were selected for further evaluation and discussion. Mean EC values ranged from a low of 7.20 dS/m in the Other waste type to 92.53 dS/m in the NaCl waste. Mean Cl values ranged from a low of 681 mg/L in the Other waste type and 1115 mg/L in the freshwater gel to 117 650 mg/L in the NaCl waste.

Statistical parameters relative to the total elemental content were provided and Cu, Cr, Ni and Zn were selected for further evaluation and discussion.

Data interpretation for land application of solid phase wastes included calculation of waste application rate (m^3 wet waste/ha), area required for land application, limiting analyte(s), and thickness of the applied waste layer (cm) for each sump sampled. Limits for land application of various analytes were developed by the DWRC and four scenarios were defined for completion of the calculations. EC, Na and Cl were limiting for about 30% of the sumps.

Calculations regarding liquid waste application rates, areas required for application, and the depth (thickness) of the waste layer that could be applied were completed. The results indicated that the limiting analytes were primarily Cl, Na, EC, and SAR.

Calculations to determine the potential application rates and areas required for application of both the liquid and solid phase waste from each sump location were completed. Of a total of 113 sumps evaluated Na, SAR, EC and Cl were limiting for 62, 46, 51, and 38 sumps respectively. Oil was limiting in four sumps at a limit of 10 000 kg/ha. Metals showing limitations were Cu, Zn, V, Cr, Ni, Cd and Pb.

ACKNOWLEDGEMENTS

We would like to recognize the support of the Canadian Petroleum Association, Independent Petroleum Association of Canada, Small Explorers and Producers Association of Canada, and the Energy Resources Conservation Board for the sampling and analytical portion of the study. We would also like to recognize the support of the Reclamation Research Technical Advisory Committee (RRTAC) in providing funds from the Alberta Heritage Savings Trust Fund, Land Reclamation Program for development of the study design and preparation of this report. We would also like to acknowledge the support of the Alberta Research Council.

We acknowledge N. Reynolds, D. Hillaby, G. Fedorak, L. Fullerton, N. Stewart, R. McAlary and W. Zubot of Nor-Chief Consulting Services (1978) Ltd. for their efforts in completing an excellent sampling program. We also acknowledge all the company and government agency personnel (see list in Appendix 1) who assisted in making this project a success.

We thank M. Korchinski and his staff of the Energy Resources Conservation Board Chemical Research Laboratory (Calgary) and the staff of the Alberta Environment Laboratory (Lethbridge) for their analytical work done on the samples.

We acknowledge the direction and support provided by the Drilling Waste Review Committee.

We recognize the following Alberta Research Council staff including J. Beres, D. Cheel, R. Faught, M. Huemmert, T. Johnson, M. Lier, C. Mascher, W. McKean, T. Pojasok, D. Reid, D. Salpeter, A. Schwarzer, D. Stein, C. Tomas, Z. Widtman and R. Xie for their help with sampling, sample transportation, sample preparation, analytical work, data management, and report preparation. We recognize the staff in the Chemical Analytical Laboratory of the Manufacturing Technologies Department (ARC) for their help in the chemical analyses of the samples. We also recognize K. Gates for completing the word processing of this report.

1. INTRODUCTION

In 1987 the joint government and industry Drilling Waste Review Committee (DWRC) was struck to update the existing guidelines/criteria (ERCB 1975) for disposal of drilling wastes in Alberta. The DWRC had representation from the following:

1. Alberta Environment
2. Alberta Forestry, Lands and Wildlife
3. Alberta Research Council (ARC)
4. Canadian Petroleum Association (CPA)
5. Energy Resources Conservation Board (ERCB)
6. Independent Petroleum Association of Canada (IPAC)
7. Petroleum Services Association of Canada (PSAC)
8. Small Explorers and Producers Association of Canada (SEPAC)

In October, 1992 the CPA and IPAC merged to form the Canadian Association of Petroleum Producers (CAPP).

The "Characterization" and "Criteria" sub-committees of the DWRC were charged with recommending characterization (sampling and analytical) protocols and criteria/guidelines for disposal. During the process the CPA funded a study to develop loading limit criteria for a defined list of analytical parameters. The criteria presented in the report prepared for the CPA raised some concerns in the drilling industry. The concerns were related to the "limits" or criteria associated with the individual parameters and whether or not specific parameters need to be evaluated at all.

Following further debate and consideration, the DWRC decided that a sump sampling and analysis project was needed to allow for the characterization of drilling wastes in Alberta. The lack of consistent and comprehensive data for sumps sampled in Alberta, and for that matter nationally and internationally, prompted the DWRC to commission the preparation of a design for an appropriate study. It was intended that the data from this study would enhance the work already done by the Reclamation Research Technical Advisory Committee (RRTAC) and the Alberta Research Council (Macyk et al. 1989) and would provide a basis for the criteria ultimately developed.

It was envisioned that the data obtained from this sampling and analytical program would be representative of drilling waste characteristics in Alberta and that the values or numbers associated with each of the parameters could be used to assist in developing criteria/guidelines regarding “limits” for the various analytes. This could be accomplished by comparing values for selected parameters or analytes to existing water or soil quality guidelines.The results of the project are reported in two volumes. This report contains a description of the sampling program, summaries of the results of the field component (well depth, mud volume) and the analytical work as well as data interpretation for land application of the liquid and solid phase wastes. **Volume II contains the statistical analysis for all analytical parameters for all waste types and all ERCB regions and is available in open file format from the Publications Office, Alberta Research Council (Box 8330, Edmonton, Alberta, T6H 5X2).**

2. OBJECTIVE

The objective of this study was to characterize a cross-section of drilling wastes from sumps throughout Alberta and to assess the feasibility of landspreading these wastes on Alberta soils. Several subobjectives were identified including:

1. sampling of representative sumps from throughout Alberta;
2. characterization of the drilling wastes by completing a prescribed suite of analyses;
3. data management and synthesis; and,
4. report preparation.

3. MATERIALS AND METHODS

The design for the study included a number of specific components relative to the sampling, characterization (analytical work), data management and synthesis, and report preparation.

3.1 ORGANIZATION AND FUNDING

The Drilling Waste Review Committee (DWRC) is the entity that oversaw the project. The study design was completed by the Alberta Research Council (Macyk and Abboud 1990) with funding from the Reclamation Research Technical Advisory Committee. The design was completed in February, 1990 and accepted by RRTAC and the DWRC in March, 1990.

The DWRC appointed a subcommittee to oversee the implementation of the study according to the design prepared. The Alberta Research Council was appointed as overall project manager and coordinator. The subcommittee was responsible for selecting a contractor to undertake the bulk of the sampling work under the direction of ARC. A bid document was prepared, submitted to potential bidders, and a contractor was ultimately selected.

The ERCB secured funding for the project by applying a surcharge to the annual administrative levy for all companies based on the number of licenced wells for a specified period of time. Approval to begin the project was received June 1, 1990.

3.2 SAMPLING

Nor-Chief Consulting Services (1978) Ltd. of Calgary was selected as the sampling contractor. They provided a coordinator and two three-man sampling crews. A field training program was conducted by ARC to familiarize the Nor-Chief crews with the sampling procedures.

3.2.1 Sampling Logistics

Two three-man crews were utilized, with one crew generally working in the southern portion of the province and the other in the remainder of the province. The sampling was coordinated so that each crew would initiate a sampling phase from central Alberta and sample enroute to the most northerly and southerly sumps selected and available at the time and then return to central Alberta. Central Alberta or locations near Edmonton (up to 200 km distant from Edmonton) were start and finish objectives for each phase to allow for sample delivery to the laboratory.

To assist with sampling, the ARC staff travelled to meet the sampling crews to collect the samples and re-stock the crews with supplies. This allowed the crews to conduct sampling without interruption and samples to be in the laboratory no more than two or three days following collection.

3.2.2 Sump Selection

The sumps sampled were selected in accordance with the study design (Macyk and Abboud 1990). Telephone inquiries were made to locate sump candidates and to obtain permission to sample. The objective was to locate as many open sumps representing different mud types as possible and to obtain information regarding the availability of sumps later in the year. The located/approved sumps were plotted and then approved for sampling by ARC. The selection of sump sites was based on:

1. study design requirement
2. crew/sampling logistics
3. length of time of availability of sumps prior to treatment or clean-up.

In many instances several calls were made to an individual company that had volunteered a sump to:

1. coordinate the sampling with rig release
2. meet with field and safety personnel
3. acquire access

A large majority of the companies assisted the study by not only providing access to the sump but also by cooperating in the coordination needed to complete the sampling without delays. Some companies postponed sump treatment and clean-up to facilitate the sampling schedule.

A total of 87 oil and gas companies and 17 mud companies were contacted. Government agencies, contractors and consulting firms were also contacted. The lists of contacts is provided in Appendix 1.

3.2.3 Sampling Protocol

All sampling, sample handling and transport methods were conducted in accordance with the study design specifications. If more than one mud system (such as gel and KCl, or gel and invert) was used at a lease site, each waste type was sampled as a separate unit. A site description (Figure 1) was completed and photographs of the site obtained.

3.2.3.1 Liquid phase sampling. The following procedure was followed in the collection of the liquid phase waste samples

1. For sumps ≤500 m^2 five locations were sampled. For sumps >500 m^2 one location for each 100 m^2 to a maximum of ten locations was sampled. The locations were random and representative of the entire sump area.
2. A maximum of 3 depth intervals were sampled. Examples of how to deal with varying depths of liquids were provided:
   a. for liquid <50 cm deep one depth sample was obtained.
   b. for liquid >50 cm and <100 one sample for the 0 to 50 cm and one for the 50+ cm interval was obtained.
   c. for liquid 100 cm deep one sample for the 0 to 50 cm depth and one for the 50 to 100 cm depth was obtained.
   d. for liquid >100 cm depth and <150 cm one sample for 0 to 50 cm, one sample for 50 to 100 cm, and one sample for the remaining depth was obtained.
3. The samples were composited on the basis of depth, therefore the samples from a given depth at each sampling point in a sump were placed in one container. A plastic lined 10 L capacity pail was excellent for this purpose. A different sampling tool was used for each separate depth sampled.

FIGURE 1. ARC - SUMP SAMPLING - SITE DESCRIPTION

Location: ____________________

Company: ____________________ Date: ____________________

Sampled by: ____________________ Sump No: ____________________

Mud Type: ____________________ Sump Vol: ____________________ m^3

Total Fluid Vol: ____________________ m^3 Total Mud Vol: ____________________ m^3

Sump: Onsite: __________ Remote: __________ Sump Freeboard: ____________________ m

Sump Type: ____________________ Sump Area: ____________________ m^2

Sump and Site Description/Observations:

4. About 1.5 L of liquid material was obtained from each depth at each sampling point. When the liquid phase sampling was completed each sample was stirred and pH measured using a Markson Model No. 88 digital pH meter.
5. Following pH measurement each individual sample was transferred into:
    a. 1 - 4 L plastic container
    b. 1 - 1 L plastic container
    c. 1 - 1 L acid washed glass jar
    and each of the containers was labelled with the sample number
6. Plastic bags used to line the pails were discarded.

    Samplers were cleaned by washing with any available natural water, rinsed with soap and distilled water and finally with distilled water prior to further use. For samples used in "oily" liquid material the sampling tool (jar) was discarded and replaced with a new one.
7. Liquid samples were placed in a cooler with ice as soon as possible after sampling and delivered to the laboratory as soon as possible. Delivery to the laboratory within 48 hours was achieved for almost all samples.
8. For sites selected for Quality Assurance/Quality Control the amount of sample material collected was doubled.
9. Sample information was recorded on a sample description form (Figure 2).

3.2.3.2 Solid phase sampling. As mentioned previously some of the wellsites had more than one sump cell at the location and often had more than one waste system present in segregated sumps. In some cases the liquid phase and solid phase materials were contained in separate cells. To determine if solids were present beneath the liquids the sump was "probed". Sump cells that contained liquid material only, generally had a thin layer of "yogurt-like" precipitated material at the base.

The native till or geologic material that formed the liner of the majority of sumps (those not lined with synthetic liners) was readily distinguished from drilling mud solids. Sometimes the solids were visible at one end of the sump which was generally the most accessible end. Very often the presence of solids in a sump was confirmed by checking for some spillage or contamination along the edge where the solids were dumped in.

The procedure described below was followed for sampling the solid phase waste materials.

1. For sumps ≤500 m^2 material representative of the entire profile or depth at each of 5 locations was collected. The locations were representative of the sump.
2. For sumps >500 m^2 one location per 100 m^2 to a maximum of 10 locations (samples) was sampled. The sampling points were all located >1 m from the sump edge.

Figure 2. SAMPLE DESCRIPTION

Sump No. ____

Hole Number	Liquid Depth	Solid Depth	Total Depth	Sample Number	Depth	Plastic		Glass	pH	L/S
						Bag	Bottle			

COMMENTS:

3. 1 - 1L glass jar and one bag (2.5 kg or more) of material were obtained. A double or triple bag system was used to ensure that the label did not become unreadable.
4. For sumps selected for Quality Assurance/Quality Control work double the amount of sample was obtained.
5. The samples were cooled and transported according to the procedure described for the liquid samples.
6. Sampling tools were cleaned as described for the liquid phase sampling.

3.2.3.3 Sampling tools. The sampling was completed by the use of four basic tools and various supplies including containers, protective clothing, etc.

A flat-bottomed boat, with a moon-bay constructed in the mid-section to enable sampling, was used for traversing the sump surfaces. For the sumps with no liquids at the surface the boat was towed by hand or winch.

The liquid wastes were sampled with the ARC discrete entity sampler. Three tools were utilized at each site to simplify the procedure. Two different tools were used for sampling the solid phase waste depending on the "consistence" of the material. For the "looser" material a nine centimeter diameter acrylic tube sampler was utilized. The acrylic tubing was prepared in 1.2 m lengths and jointed with a coarse thread stainless steel coupler. The bottom was open ended and the top end was sealed and fitted with an air line connected to a handheld one way air valve. A stainless steel open-ended split spoon was also utilized at several sumps where the solid phase was too firm to penetrate with the tube samplers.

In addition to the tools a supply of sample containers and cleaning compounds and accessories were utilized. Portable coolers were also used for transporting the samples from the field to the laboratory.

Polypropylene containers with a capacity of 1 L, 2 L and 4 L were used to hold the liquid materials. An acid-washed glass jar (1 L capacity with teflon lid) was used for the liquid samples that were subjected to analysis for organic compounds. For sample collection a 5 mil polypropylene bag was placed in a 10 L capacity pail for collection of the subsamples for compositing.

For the solid waste materials acid-washed 1 L capacity glass jars with teflon lid and polypropylene bags (3 mil) were used.

The labels, which complied with Transportation of Dangerous Goods regulations, were pre-made in the office using a sticky backed material for ease of affixing the label to the container. The cleaning materials included a laboratory soap (Liqui-Nox), isopropanol, distilled water and paper towels etc.

3.2.3.4 Safety equipment. The safety equipment used was related to the sampling equipment used and personal clothing and gear.

Hydrogen sulphide sniffers were utilized to assess whether the sump locations were safe to work in. Crews had to abandon sampling at a few locations because of the presence of unsafe levels of H_2S. Safety equipment associated with the use of a boat included a lifeline, life jackets for the crew, and a crew member on shore at all times. A flat-bottomed boat was also used for greater stability. Personal safety gear included the following:

1. neoprene or surgical gloves
2. oil resistant footwear
3. protective coveralls

3.2.3.5 Field problems encountered. High rainfall amounts during June and July presented the most problems for sampling. When sampling was initiated in mid-June, access in west central Alberta was very limited, therefore crews sampled the more northerly and southerly locations with very limited access to foothills locations. Even in late July one crew still had difficulty in accessing sumps in western Alberta and time was lost in attempting to access sites. Muddy road conditions in northwest Alberta also increased sampling times during July. Other lost time situations included:

1. high H_2S levels at sump site resulted in abandoning sampling
2. locked gate restricting access to site
3. candidate sump cleaned (backfilled) prior to sampling crew arrival.

3.3 ANALYTICAL PROCEDURES

This section describes the materials and methods used for the analysis of the waste and source water samples. A major portion of the analytical work was conducted in the laboratories of the Alberta Research Council with Quality Assurance/Quality Control work done by the Energy Resources Conservation Board (ERCB) Chemical Research Laboratory in Calgary and the Alberta Environment Laboratory in Lethbridge. In addition, staff in the ERCB Laboratory conducted the Trout Bioassays.

All samples collected were submitted to the Alberta Research Council Soils Laboratory. From there the specific samples, subsamples and/or composite samples were prepared and transported to the Calgary and Lethbridge laboratories. Methods employed by the different laboratories are provided below.

The date and time that samples were received was recorded. All sample numbers were recorded and checked against field records to ensure that all samples had been received.

3.3.1 Liquid Phase Samples (ARC Laboratory)

The liquid phase samples were kept at 4°C upon receipt at the laboratory and samples for QA/QC and Trout Bioassay were transported at 4°C to the respective laboratories. The remaining samples were prepared for analysis within two working days of receipt in laboratory. Approximately 120 g of sample was placed in a teflon beaker and dried at 105°C for 24 hrs. to determine total dispersed solids (total residue) (APHA 1980).

About 200 mL of the sample was centrifuged at 15 000 rpm for 15 minutes and then filtered through a 0.45μm filter. The supernatant was then analysed for pH using a Radiometer combination electrode and Radiometer PHM82 pH meter. Electrical conductivity was determined with a Yellow Springs Instruments conductivity cell and model 32 conductance meter. Alkalinity and chloride were measured according to EPA methods 310.2 (EPA 1983) and 325.2 (EPA 1983), respectively using a Lachat flow injection analysis (FIA) instrument. Ammonium (NH_4) was measured according to EPA method 350.1 and nitrate (NO_3) according to EPA method 353.2 (EPA 1983) using a Lachat flow injection analysis instrument. The soluble ions including Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Se, Si, Sr, Ti, V, and Zn were measured using an ARL model 34000 simultaneous Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES).

The benzene, toluene, ethylbenzene, and xylene (BTEX) analyses were completed by the Oil Sands and Hydrocarbon Recovery Department Laboratory of the Alberta Research Council. The analyses were done by gas chromatography and flame ionization detection. A Hewlett Packard 5890 gas chromatograph equipped with a DB-Wax column 30 m in length and having a diameter of 530 µm was used. The GC parameters used were:

Detector	300°C
Injector	ambient temperature
Oven Initial Temperature	40°C
Initial Temperature	3.0 minutes
Oven Final Temperature	100°C
Rate	5°C per minute
Final Time	0.0 minutes

Oil and grease in the liquid samples was measured according to Method 503 B of APHA (1980).

3.3.2 Liquid Phase Samples (ERCB Laboratory)

Upon receipt the samples were composited if required and stored in a walk-in refrigerator at 4°C. To prepare a composite sample for each sump the individual samples were mixed manually and then composited in equal proportions to a total weight of 3600 g. These composite samples were then mixed manually for several minutes before analysis. The samples were then analyzed for trout bioassay (LC(50)).

The individual or non-composite samples for quality control measurement were filtered through a 0.45 µm filter paper before analysis for selected parameters. Muddy samples or samples containing a greater proportion of solids were pressure filtered through a Whatman 50 hardened filter paper before filtering through a 0.45 µm filter paper.

The trout bioassay was completed by a procedure adapted from the technique described by Environment Canada (1980) and the ERCB 96 hour static trout bioassay.

3.3.3 Solid Phase Samples (ARC Laboratory)

Upon arrival at the laboratory the solid samples were removed from the jars and subsamples removed for submission to the ERCB laboratory for the Trout and Microtox bioassays. These samples were placed in glass jars and transported in coolers or ice-filled trays. The remaining portion of the samples were then air-dried and ground for determination of oil and grease. The solid phase samples contained in polypropylene bags were spread to air-dry in plastic lined trays. A small subsample was removed from each to determine moisture content based on drying the sample at 105°C for 24 hrs.

The air-dried samples were ground to pass through a 2 mm stainless steel sieve. The invert samples were hand ground because the oily material would have plugged the automated grinding equipment. The following analyses were completed on all samples except where noted.

The pH was measured in a water paste (Doughty 1941) and in a 2:1 slurry of 0.01 M $CaCl_2$ (Peech 1965).

Total carbon content was measured with a LECO CR12 carbon analyser (Leco Corporation 1979), and $CaCO_3$ equivalent by acid dissolution (Bascomb 1961). Acid neutralizing capacity by addition of 0.5 M HC1 and back titration with 0.25 M NaOH (methods 1.004 and 1.005 (AOAC 1981)) was completed on one composite sample per sump.

Saturated pastes were prepared according to the USDA Soil Salinity Laboratory method (USDA 1954). They were extracted and the extracts filtered through a 0.45μm filter and analyzed: for pH using a Radiometer combination electrode and Radiometer PHM 82 pH meter; for electrical conductivity using a Yellow Springs Instruments conductivity cell and model 32 conductance meter; for alkalinity (EPA method 310.2 (EPA 1983)) and chloride (EPA method 325.2 (EPA 1983)) with a Lachat flow injection analysis (FIA) instrument; and for the soluble ions (Na, K, Ca, Al, Cr, Fe, V, Ti, Cd, Cu, Pb, Zn, Mn, Mg, Li, Sr, B, Ba, P, S, Mo, Ni, Se, As, Co, Si) using an ARL model 34000 simultaneous Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES). Ammonium (NH_4) and nitrate (NO_3)were measured according to EPA methods 350.1 and 353.2 (EPA 1983) respectively using a Lachat flow injection analysis instrument.

Cation exchange capacity (CEC) and extractable cations in one composite sample per sump were determined by extractions with a normal (1 M at pH 7.0) ammonium acetate solution or ammonium chloride solution for those samples containing carbonates (Holmgren et al. 1977). The NH_4 ions were determined by a Tecator Kjeltec Auto 1030 Analyser distillation and titration unit and exchangeable Ca, Mg, K, and Na by ICP-AES.

Particle size analysis was done using a simplified hydrometer method (Gee and Bauder 1979).

DTPA-NH_4HCO_3 extractable elements (Fe, Cd, Cu, Pb, Zn, Mn, Ca, Mg, Na, K, B, P, Mo, Ni, Se) were determined by the method of Soltanpour and Workman (1981). Total element analysis of the solid sump samples was done by digestion in a CEM microwave digestion system. The procedure used included ashing the material overnight in a 425°C muffle furnace, digestion in a teflon bomb in the microwave oven with 1.5 mL HNO_3, 4.5 mL HCl and 10 mL HF for 10 minutes at 100% power, 20 minutes at 50% power, and 10 minutes at 100% power. The digested solutions were transferred and made up with saturated H_3BO_3 to 50 mL, and the metal concentrations measured using ICP-AES. Oil content in the samples was measured gravimetrically by soxhlet extraction with methylene chloride (McGill and Rowell 1977).

The relative acute toxicity of the waste sample was determined by the Microtox TM (bacterial bioluminescence assay) technique using the method of Matthews and Hastings (1987).

3.3.4 Solid Phase Samples (ERCB Laboratory)

Upon receipt the samples were composited as required and stored in a walk-in refrigerator at 4°C. A 10% water soluble extract was prepared using Milli-Q demineralized water as the diluent. The 10% extract was shaken for 1 hour on a mechanical shaker and allowed to stand for 24 hours prior to analysis. The 1% water soluble extract was prepared by completing a 10% dilution of the 10% extract solution.

Composite samples were composited by weight in equal proportions to a total weight of 1600 g and water soluble extracts prepared as needed.

The trout bioassay was completed as described in section 3.3.2.

4. RESULTS AND DISCUSSION

4.1 SAMPLING SUMMARY

The sampling program began June 5, 1990 with a meeting of all Nor-Chief staff, T. Macyk, Z. Widtman and R. Creasey to discuss the study outline and the sampling protocol. On June 12 and 13, ARC and Nor-Chief staff sampled three sumps during the field training program. The Nor-Chief sampling program wound down on August 3 to allow the ARC laboratory to deal with the samples obtained and for decisions to be made regarding the sampling program. The sampling program resumed on October 15, 1990 and was completed on October 19, 1990. A sampling demonstration was conducted at a sump location in the Innisfail area on October 16, 1990 with representatives of the private and public sectors in attendance.

Approximately 50% of the sumps sampled resulted from the previous winter drilling program with the remainder representing sampling shortly after rig release.

The sampling program included the collection of samples from 128 individual sumps or physical structures at 114 different geographic locations (Figure 3). At seven locations more than one facility was sampled. These locations had different mud systems contained in separate cells. In locations where the liquid phase and solid phase materials were contained in separate cells the designations for the cells were for example - 14A, 14B. The sampling program yielded the following waste type distribution on the basis of number of sumps sampled.

Waste type	Number Sampled	Number Projected
freshwater gel	72 sumps	50
invert	19 sumps	15
KCl	27 sumps	25
NaCl	2 sumps	5
Other	8 sumps	5
	128 sumps	100

The "Other" category included K_2CO_3, SAPP-Polymer, K-Acetate, Metal-OH, and SAPP-K mud types.

The program yielded the following sample distribution:

Sample type	Number Obtained	Number Projected
Liquid phase	288	300
Solid phase	653	500
QA/QC	9	10
Source water	30	-

A very effective sampling program resulted in exceeding the targeted total number of sumps. The numbers of sumps targeted relative to waste type were generally achieved or exceeded. The numbers for KCl and invert were very close to the expected numbers. The NaCl waste type target was not achieved simply because of a lack of use of the mud type. The freshwater gel target was exceeded because of the dominant use of the gel mud type and because gel sumps almost always occurred at locations where other waste types were sampled.

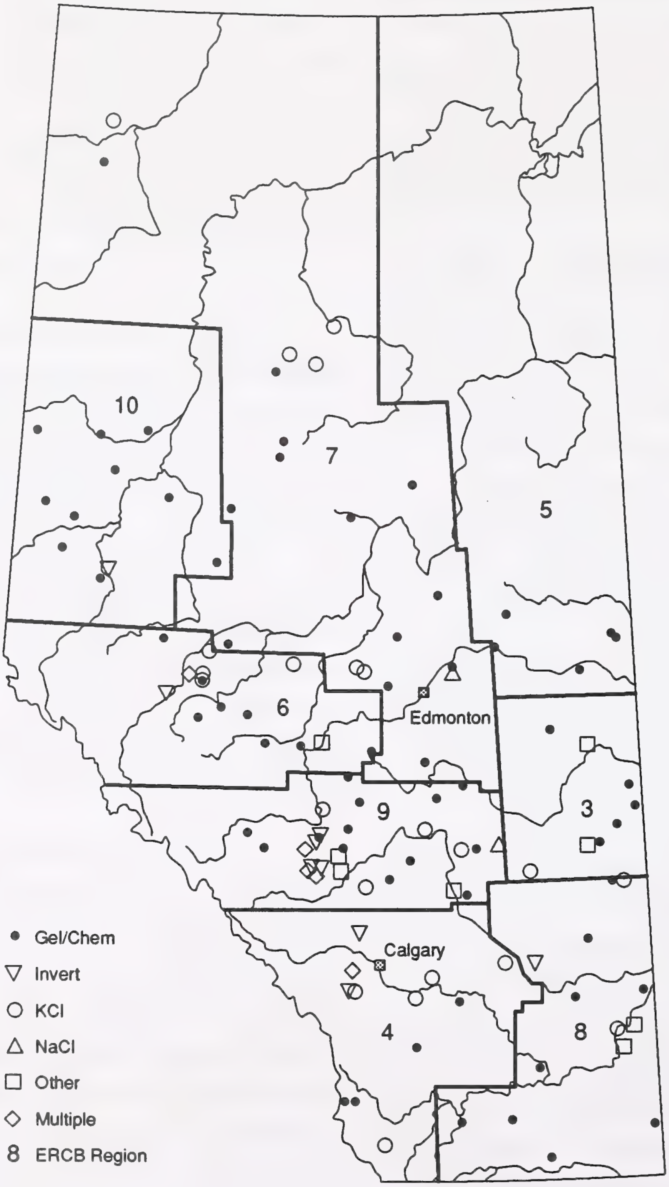


Figure 3. Location of sump sampling sites.

The number of individual samples obtained exceeded expectations, in part due to the larger number of sumps sampled than originally anticipated. For the liquid phase samples an estimate of 3 samples per sump for 100 sumps was made. In fact many of the sumps had less than 3 depths to be sampled resulting in less than the expected number. For the solid phase samples an estimate of 5 samples per sump for 100 sumps was made. Several of the sumps required more than 5 samples to be obtained on the basis of the sampling protocol utilized. No initial estimate of source water sample numbers was established except to obtain as many as possible.

4.2 SUMP LOCATION/SAMPLE DISTRIBUTION

The locations for the sites sampled are illustrated in Figure 3. Table 1 provides a summary of the number of sumps sampled for each ERCB region.

Overall coverage of the province was excellent. About 50% of the sumps sampled were located in ERCB regions 4, 6 and 9 which includes the Foothills region of the province.

4.3 WELL DEPTH AND MUD VOLUME

Information with respect to well depth relative to the sumps sampled was provided by the companies and the ERCB. Mud volume was estimated from the measurements taken by the field crews.

Data for well depths and mud volumes for all locations are provided in Appendix 2. Statistical parameters for well depth and mud volume for all locations sampled are provided in Table 2. The term location rather than sump is used because at some well locations more than one sump was sampled. It should be noted that well depth data were available for 106 sumps out of the total number sampled.

Tables 3, 4 and 5 provide summary data with respect to well depth and waste type. The data in Table 3 indicate a relatively uniform number of wells for each of the depth intervals except for those less than 500 m or greater than 4000 m. Table 4 indicates that most of the gel wells were between 501 m and 4000 m, while a significant number of the KCl and invert wells were greater than 3000 m. The data in Table 5 indicate that the deepest wells drilled occurred west of the 5th meridian where the mean depth was slightly higher than in areas west of the 6th meridian, but more than 2.5 times greater than the mean depth for wells west of the 4th meridian.

Tables 6, 7 and 8 provide summary data relative to mud volume. The data in Table 6 indicate that 74% of the sumps sampled had a mud volume less than or equal to 1000 m^3 or about 6000 barrels. About one-quarter of the sumps had volumes less than or equal to 300 m^3. Table 7 provides a distribution of sumps on the basis of volume relative to waste type. The largest mean mud volume occurred at well locations west of the 6th meridian which was almost 30% higher than volumes west of the 5th meridian and 4.5 times those found west of the 4th meridian (Table 8).

Table 1. Number of Sumps Sampled Relative to Waste Type and ERCB Region.

ERCB Region	Waste Type	Number of Sumps Sampled	Total
3	Gel	5	7
	KCl	1	
	Other	1	
4	Gel	5	17
	Invert	5	
	KCl	7	
5	Gel	4	4
6	Gel	8	18
	Invert	2	
	KCl	6	
	Other	2	
7	Gel	13	21
	KCl	7	
	NaCl	1	
8	Gel	10	15
	Invert	1	
	KCl	2	
	Other	2	
9	Gel	16	35
	Invert	10	
	KCl	4	
	NaCl	1	
	Other	4	
10	Gel	10	11
	Invert	1	

The information presented in Table 1 provides an indication of the regions or portions of the province where specific mud types are used. Obviously the freshwater gel and KCl muds are universally used whereas the NaCl and invert are associated with more defined regions. The ERCB Regions are administrative regions.

Table 2. Statistical Parameters for Well Depths and Mud Volumes (all locations).

Variable Vol.	Well Depth, m	Mud Vol.	Solid Vol.	Liquid
		-----------------------------m3	------------------------	
Count (N)	106.00	106.00	106.00	105.00
Mean	2053.09	1073.87	546.69	534.78
Median	1747.50	625.50	298.00	303.00
StDev (sd)	1243.55	1518.19	1096.85	664.18
Maximum	5443.00	12210.00	10395.00	4146.00
Minimum	297.00	40.00	0.00	0.00

Table 3. Well Depths Relative to Sumps Sampled.

Well depths (m)	Number	% of Total
0 - 500 m	5	5
501 - 1000 m	20	18
1001 - 1500 m	18	17
1501 - 2000 m	15	16
2001 - 3000 m	25	22
3001 - 4000 m	15	15
> 4000 m	8	7

Table 4. Distribution of Sumps Sampled by Well Depth and Waste Type.

Well Depth (m)	Gel Total	KCl	Invert	NaCl	Other
0 - 500	2	1	2	0	5
500 - 1000	14	3	1	0	20
1001 - 1500	13	3	0	0	18
1501 - 2000	11	4	0	0	15
2001 - 3000	15	2	4	2	25
3001 - 4000	5	8	2	0	15
> 4000	3	0	5	0	8

Table 5. Well Depths Relative to Location (Meridian).

Location	N	Depth (m) Mean	Max.	Min.
West of 4th Meridian	41	1106	2085	425
West of 5th Meridian	54	2697	5443	297
West of 6th Meridian	11	2421	3960	1495
All	106	2053	5443	297

Table 6. Mud Volume Relative to Sumps Sampled.

Mud Volume (m^3)	Number	% of Total
0 - 300 m^3	26	25
301 - 500 m^3	18	17
501 - 1000 m^3	34	33
1001 - 1500 m^3	10	9
1501 - 2000 m^3	9	8
> 2000 m^3	9	8

Table 7. Distribution of Sumps Sampled by Mud Volume and Waste Type

Mud Volume (m^3)	Gel	KCl	Invert	NaCl	Other	Total
0 - 300	13	7	4	0	2	26
301 - 500	11	1	4	1	1	18
501 - 1000	20	8	3	0	3	34
1001 - 1500	4	4	0	0	2	10
1501 - 2000	7	1	1	0	0	9
> 2000	8	0	1	0	0	9

Table 8. Mud Volumes Relative to Well Location (Meridian).

Location	N	Mud Volume (m^3) Mean	Max.	Min.
West of 4th Meridian	43	402	880	40
West of 5th Meridian	52	1458	12210	113
West of 6th Meridian	11	1884	3396	502
All	106	1074	12210	40

4.4 ANALYTICAL RESULTS

The analytical work was completed according to the study design of Macyk and Abboud (1990). The data pertinent to the various analyses for the liquid and solid phase samples were submitted to members of the Drilling Waste Review Committee as they became available. A set of five discrete tables provided the results of the liquid phase analyses for the five waste type categories. Tables of data for the solid phase chemical and physical properties, saturated paste extract properties, DTPA-NH_4HCO_3 values, and the total elemental analysis for the five waste types were also provided.

The above mentioned tables contain data for all parameters for all samples and are not included in this publication because of the sheer volume of the paper required. These tables are on file with the authors in hard copy form. Statistical analysis was undertaken to summarize the data in a systematic manner. Measures tables were prepared providing count (N), mean, median, standard deviation, maximum, and minimum. These tables were prepared utilizing the following format for all samples on the basis of:

1. liquid phase samples in Appendix 29 of Volume II.
2. solid phase samples in Appendices 30 to 33 of Volume II.
    - chemical and physical properties
    - saturated paste extract properties
    - DTPA extractable elements
    - total elemental analysis

For each of the five groupings above the following statistical parameter tables were prepared:

1. statistical parameters for all samples
2. statistical parameters for all waste type samples (gel, invert, KCl, NaCl and Other).
3. statistical parameters for all samples in each ERCB Region (3, 4, 5, 6, 7, 8, 9 or 10).
4. statistical parameters for each waste type in each ERCB Region.

The discussion of the data and the mode of presentation can be done in several different ways and with varying degrees of detail. With the volume of data generated in this study, and keeping in mind the study was to characterize drilling wastes from throughout the province, the following discussion is provided. **The assumption made at the outset was that the sumps sampled and samples obtained therefrom are representative of the wastes generated in the province.**

The values or numbers associated with each of the analytical parameters may be used to assist in developing criteria/guidelines regarding "limits" for the various analytes. There are two approaches that can be taken to synthesize or reduce the volume of data generated. First of all, comparisons of values for selected parameters or analytes relative to waste type and/or ERCB region can be made. Secondly, the values or numbers associated with each of the analytical parameters may be used to assist in developing criteria/guidelines regarding “limits” for the various analytes. This could be done by comparing values for selected parameters or analytes to existing water or soil quality guidelines.

4.4.1 Liquid Phase Data

Table 9 provides statistical parameters for all of the liquid waste samples combined. For discussion purposes it is not possible to discuss each individual parameter. Appendix 3 contains statistical parameters for the individual waste types. The remaining statistical analysis tables are included in Appendix 29 of Volume II. Please note that although 288 liquid phase samples were collected a total of 281 samples were analyzed due to the combining of samples from separate sumps or cells at a given wellsite location.

4.4.1.1 All Liquid Phase Data. To reduce the number of parameters dealt with, the maximum values for all parameters reported in Table 9 were compared to maximum acceptable concentrations of constituents in Canadian waters for irrigation prepared by the Task Force on Water Quality Guidelines of the Canadian Council of Resource and Environment Ministers (CCREM 1987). The CCREM guidelines are presented in Table 10. Comparison of the data to irrigation water quality guidelines is relevant because much of the drilling waste liquid phase material is pumped on to or squeezed into the landscape.

In completing the comparison described above it became apparent that the parameters which warranted attention were EC, Cl, Al, Cr, Fe, and oil content.

For all liquid samples the EC values ranged from 0.14 to 149 dS/m with a mean of 7.34 dS/m. The maximum tolerable level for irrigation water is about 5 dS/m. The Cl values ranged from 5.21 to 117 000 mg/L with a mean value of 2865 mg/L whereas the maximum acceptable level for irrigation water is 700 mg/L.

The Cr values ranged from 0.01 to 3.59 mg/L with a mean value of 0.13 mg/L. The maximum value of 3.59 mg/L exceeded the maximum acceptable concentration of 1.0 mg/L. The B values ranged from 0.02 to 3.39 mg/L with a mean value of 0.44 mg/L whereas the range for maximum acceptable concentrations for irrigation is 0.5 to 6.0 mg/L.

Oil content in the liquid phase waste samples ranged from 0.33 to 106 000 mg/L with a mean value of 1884 mg/L whereas the maximum acceptable concentration is about 5000 mg/L.

Table 9. Statistical Parameters of the Liquid Phase Samples.

Parameter	pH		E.C.	Cl	NH4	Alk.	HCO3	CO3	OH	NO3-N	Al	Cr
	Lab	Field					(mg/L)					
Count (N)	281.00	264.00	281.00	281.00	281.00	281.00	281.00	281.00	281.00	281.00	281.00	281.00
Mean	8.92	8.99	7.34	2864.54	1.76	439.26	306.71	95.93	36.71	7.53	2.31	0.13
Median	8.62	8.98	3.03	240.00	0.25	322.00	223.00	11.30	0.21	0.06	1.00	0.01
StDev (sd)	1.22	1.38	15.00	11873.54	3.88	495.30	334.87	253.96	153.93	37.90	8.73	0.36
Maximum	12.40	12.50	149.00	117000.00	41.90	5080.00	2650.00	2430.00	1070.00	300.00	128.00	3.59
Minimum	5.70	5.14	0.14	5.21	0.00	15.60	0.00	0.00	0.00	0.00	0.10	0.01

Parameter	Fe	V	Ti	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na	K	Li
							(mg/L)						
Count (N)	281.00	281.00	281.00	281.00	281.00	281.00	281.00	281.00	281.00	281.00	281.00	281.00	281.00
Mean	1.30	0.05	0.09	0.01	0.02	0.07	0.15	0.17	148.64	21.30	1576.65	737.28	0.07
Median	0.40	0.02	0.02	0.01	0.01	0.05	0.10	0.03	49.50	4.65	667.00	14.90	0.05
StDev (sd)	3.52	0.07	0.40	0.00	0.02	0.04	0.21	0.49	288.42	53.29	6675.18	2375.13	0.11
Maximum	40.60	0.65	5.48	0.02	0.15	0.29	1.63	6.19	3100.00	413.00	79600.00	15500.00	0.99
Minimum	0.01	0.02	0.01	0.01	0.01	0.05	0.01	0.00	2.63	0.05	6.20	1.59	0.02

Parameter	Sr	B	Ba	P	Mo	Ni	Se	Co	SO4	Si	As	T.Residue
								(mg/L)				g/L
Count (N)	281.00	281.00	281.00	281.00	281.00	281.00	281.00	281.00	281.00	281.00	281.00	281.00
Mean	1.83	0.44	0.25	2.10	0.10	0.03	0.17	0.01	963.23	12.02	0.07	66.25
Median	0.66	0.29	0.10	0.22	0.08	0.02	0.15	0.01	576.00	6.33	0.04	34.50
StDev (sd)	3.88	0.48	0.49	6.58	0.11	0.02	0.08	0.01	1052.23	24.42	0.09	80.67
Maximum	46.60	3.39	4.24	52.60	1.13	0.12	0.90	0.04	6210.00	333.00	1.06	534.00
Minimum	0.03	0.02	0.00	0.05	0.03	0.02	0.15	0.00	6.51	0.05	0.02	0.12

Parameter	EC50		Oil	Benzene	Toluene	Ethyl Benzene	P-Xylene	M-Xylene	O-Xylene	Trout	
	5min(%)	15min(%)	mg/L			(mg/Kg)				LC50(%)	Survival
Count (N)	135.00	134.00	115.00	126.00	126.00	126.00	126.00	126.00	126.00	123.00	115.00
Mean	45.74	43.88	1884.51	0.72	0.06	0.07	0.03	0.03	0.07	30.19	0.43
Median	32.80	28.70	2.59	0.03	0.03	0.03	0.03	0.03	0.03	16.00	0.00
StDev (sd)	38.75	39.05	10631.07	2.31	0.28	0.38	0.02	0.08	0.39	33.80	0.97
Maximum	100.00	100.00	106000.00	14.50	2.71	4.16	0.26	0.96	4.35	100.00	3.00
Minimum	0.15	0.13	0.33	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.00

E.C. = Electrical Conductivity (ds/m); Alk = Alkalinity (mg CaCO3/L); HCO3, CO3, OH reported as mg CaCO3/L; T.Residue = Total Residue (g/L); Microtox Analysis = EC50 (5 or 15 minutes); Trout (LC50(%)) = Concentration of solution lethal to 50% of the trout in 96 hours of exposure; Trout Survival = Number of 3 possible fish that survive for 96 hours.

Table 10. Maximum Acceptable Concentrations (mg/L) of Various Constituents in Canadian Waters.

Constituent	Drinking Water	Aquatic Life Freshwater	Irrigation Water	Livestock Drinking Water
Al	-	0.005-0.1	5-20	5.0
As	0.05	0.05	0.1-2.0	0.5-5.0
Ba	1.0	-	-	-
B	5.0	-	0.5-6.0	5.0
Cd	0.005	0.0002-0.0018	0.01	0.02
Ca	-	-	-	1000
Cl	250	-	100-700	-
Cr	0.05	0.02-2.0	0.1	1.0
Co	-	-	0.05-5.0	1.0
Cu	1.0	0.002-0.004	0.2-5.0	0.5-5.0
Fe	0.3	0.3	5.0-20	-
Pb	0.05	0.001-0.007	0.2-2.0	0.1
Li	-	-	2.5	-
Mn	0.05	-	0.2-10	-
Hg	0.001	0.0001	-	0.003
Mo	-	-	0.01-0.05	0.5
Ni	-	0.025-0.150	0.2-2.0	1.0
Se	0.01	0.001	0.02-0.05	0.05
SO_4	500	-	-	1000
V	-	-	0.1-1.0	0.1
Zn	5.0	0.03	1.0-5.0	50
pH	6.5-8.5	6.5-9.0	-	-
TDS	500	-	500-3500	3000

From CCREM (1987).

The parameters and the respective selected potential maximum acceptable levels in drilling waste liquid phase materials used for interpretation purposes are presented in Table 11. The reason for the selected value of 1.0 mg/L for Cr in Table 11 as compared to 0.1 mg/L in Table 10 is that the irrigation value represents a maximum concentration of 0.1 mg/L for continuous or multiple applications whereas the drilling waste application is intended to be a one-time event. The 5000 mg/L value for oil content was based on results in the literature and discussion with the Drilling Waste Review Committee. It must be emphasized that THE VALUES PRESENTED ARE A MEANS FOR COMPARISON AND INTERPRETATION OF THE DATA AND ARE NOT RECOMMENDED VALUES.

The criteria for potential maximum acceptable levels were compared to the liquid phase data and Table 12 was generated. Table 12 provides a listing of the specific sumps and the respective samples that had values exceeding the potential maximum acceptable limits selected.

Table 11. Maximum Potential Acceptable Levels of Selected Parameters in Liquid Phase Drilling Wastes.

Parameter	Potential maximum acceptable level*
EC	5 dS/m
Cl	700 mg/L
Al	20 mg/L
Cr	1.0 mg/L
Fe	20 mg/L
Oil content	5000 mg/L

* These are not recommended values but rather a means for comparison and interpretation of the data.

A total of 123 samples from 71 sumps had one or more parameters that exceeded the limits selected with EC and chloride levels creating the limitation for most of the samples. These 123 samples represented all of the major waste types and all the regions.

Oil content was limiting for a total of eight samples including six invert and two freshwater gel wastes from five different regions. A review of the site description data for the two freshwater gel samples indicated that an oil slick was present on the waste surface at the time of sampling.

A total of nine samples had Cr levels that exceeded the limit selected including eight samples of freshwater gel and one KCl sample from five different regions. The Cr values for the nine samples generally did not exceed the proposed limit to a great extent and could possibly reflect one of the additives used in the drilling of the respective wells.

The Fe and Al values exceeded the selected maximum acceptable levels in four samples. For sumps SC38 (gel) and SC63 (gel) both Fe and Al were above the limit selected. For sump SC37 (polymer) the Al value was limiting and SC30 (KCl) the Fe value was limiting.

Table 12. Listing of Samples That Exceed Potential Maximum Acceptable Limits for Specific Criteria.

Sample Number	ERCB Region	Waste Type	E.C. (dS/m)	Cl	Al	Cr	Fe	Oil (mg/L)
				----------	(mg/L)	--------		
SC4-1	6	KCl		2810		1.36		
SC4-2	6	KCl	16.90	15000				
SC5-1	6	Gel	7.80	6220				
SC6-1	6	Invert		1030				9610
SC9A-1	4	Gel	8.30					
SC9B-2	4	Invert		805				
SC9B-3	4	Invert	7.64	938				
SC9D-1	4	Invert	5.31	1470				106000
SC12-1	4	KCl	22.30	8220				
SC13-2	8	Gel	5.35					
SC13-3	8	Gel	5.71					
SC18-1	8	Gel		1050				
SC18-2	8	Gel				1.01		
SC19A-1	4	KCl	13.30	3500				
SC19A-2	4	KCl	15.70	4180				
SC19A-3	4	KCl	16.30	4510				
SC21-1	7	Gel		3230				
SC27-1	7	Gel				2.23		
SC28-2	7	Gel	5.54	986				
SC29-1	7	KCl	5.96	1760				
SC29-2	7	KCl	9.55	3250				
SC29-3	7	KCl	48.30	20100				
SC30B-1	7	KCl	20.10	6490				
SC30B-2	7	KCl	32.20	10900			26.8	
SC31A-3	7	KCl		947				
SC31B-4	7	KCl	20.90	6970				
SC31B-5	7	KCl	30.10	9970				
SC31B-6	7	KCl	21.50	7320				
SC34-1	6	Gel	6.45					
SC34-2	6	Gel	10.30					
SC36-1	6	KCl	31.70	11100				
SC36-2	6	KCl	43.40	14500				
SC37-3	6	POLYMER			34.0			
SC38-3	6	POLYMER			61.5		21.4	
SC39-2	9	Gel	5.18					
SC39-3	9	Gel	5.38					
SC40-3	9	Gel	5.94					
SC42-3	7	Gel	5.88					
SC43-2	10	Gel	5.95	751				
SC44-1	7	Gel		720				
SC44-2	7	Gel	12.30	1110				
SC44-3	7	Gel	7.40	1000				
SC45-2	10	Gel	5.99			1.31		
SC46-1	10	Gel		880				5800
SC46-2	10	Gel	8.20	1230				
SC49-1	10	Gel		734				
SC49-3	10	Gel	5.36					

Table 12 (Continued). Listing of Samples That Exceed Potential Maximum Acceptable Limits for Specific Criteria.

Sample Number	ERCB Region	Waste Type	E.C. (dS/m)	Cl	Al	Cr	Fe	Oil (mg/L)
				(mg/L)				
SC50-1	10	Gel	5.06					
SC50-2	10	Gel	7.15			1.34		
SC50-3	10	Gel	8.33					
SC52A-1	9	NaCl	5.78	6620				
SC52A-2	9	NaCl	13.00	17500				
SC52A-3	9	NaCl	33.00	101000				
SC52B-1	9	NaCl		1130				
SC52B-2	9	NaCl		1160				
SC53-1	3	KCl		995				
SC53-2	3	KCl	5.75	1540				
SC53-3	3	KCl	5.66	1750				
SC56A-1	4	KCl	54.80	19600				
SC56B-1	4	KCl	28.60	9150				
SC56C-1	4	KCl	28.30	9180				
SC58-1	4	KCl	19.60	6510				
SC58-2	4	KCl	30.10	10600				
SC59-3	9	KCl	11.60	3490				
SC60-2	9	K2C03	5.54					
SC60-3	9	K2C03	10.70	741				
SC61-1	9	Invert	10.50					
SC61-2	9	Invert	15.30	912				
SC62A-1	9	Invert						18500
SC62C-3	9	Gel	5.69					
SC62D-1	9	Invert						5360
SC62D-2	9	Invert		1050				
SC62D-3	9	Invert	11.80	2330				
SC63-3	8	Gel			128.0		40.6	
SC64-1	8	Gel	7.68					
SC64-2	8	Gel	9.78			1.03		
SC64-3	8	Gel	10.70					
SC66-1	8	SAPP (POLYMER)		1180				
SC72B-3	9	Invert		915				
SC74-1	9	KCl	8.10	1780				
SC74-2	9	KCl	11.90	2080				
SC80-2	10	Gel	5.66					
SC80-3	10	Gel	5.25					
SC81A-1	10	Invert	7.86	2800				
SC81B-1	10	Invert		1420				
SC81C-1	10	Invert	6.91	2000				
SC82-3	6	Gel				1.24		
SC83-2	6	Gel				1.60		
SC85-2	7	Gel		859				
SC87-1	5	Gel				3.59		
SC87-2	5	Gel	5.56					

Table 12 (Concluded). Listing of Samples That Exceed Potential Maximum Acceptable Limits for Specific Criteria.

Sample Number	ERCB Region	Waste Type	E.C.	Cl	Al	Cr	Fe	Oil
			(dS/m)	(mg/L)				(mg/L)
SC93A-1	3	Gel	11.10	6960				
SC93A-2	3	Gel	9.71	6720				
SC93B-8	3	Gel	11.80	7840				23300
SC93B-9	3	Gel	13.40	9760				
SC93B-10	3	Gel	13.10	7560				
SC94-3	9	Gel		791				
SC97-1	9	K-ACETATE	6.17					
SC97-3	9	K-ACETATE	5.13					
SC98-1	9	KCl	32.00	9640				
SC98-2	9	KCl	38.30	12500				
SC99-1	9	Invert		1210				7520
SC102-1	9	KCl	30.50	11300				
SC102-2	9	KCl	38.90	14600				
SC104-1	3	SAPP - K	5.96					
SC104-2	3	SAPP - K	6.03					
SC105-1	7	KCl	13.80	4750				
SC105-2	7	KCl	20.90	7480				
SC106-1	7	KCl	17.90	6240				
SC106-2	7	KCl	28.20	8980				
SC106-3	7	KCl	31.00	10500				
SC107-1	6	KCl	11.30	2300				
SC107-7	6	KCl	8.59	1210				
SC107-8	6	KCl	17.00	2390				
SC108-1	6	Invert						30800
SC108-2	6	Invert	6.74	1020				
SC108-12	6	Invert	8.88	3550				
SC201-1	9	Gel		900				
SC201-2	9	Gel		983				
SC205-1	8	KCl	41.40	16700				
SC205-2	8	KCl	46.30	16400				
SC206-1	7	NaCl	148.00	117000				
SC206-2	7	NaCl	149.00	116000				

The limitation due to Fe and Al could possibly be attributed to the presence of aluminosilicates that passed through the filter in the sample preparation process.

4.4.1.2 Comparison of Waste Types and Regions. Another approach to interpreting the analytical data and statistical tables generated is to compare the values for specific parameters between waste type and then between regions for a given waste type. Tables 13 to 18 provide a comparison of EC, Cl, Al, Cr, Fe, and oil content respectively for the gel, KCl, NaCl, invert, and Other waste types for the entire province. Please note that minimum values of 0.10 mg/L and 0.01 mg/L represent detection limits for the respective elements.

The trends for EC (Table 13) and Cl (Table 14) are comparable with NaCl wastes having the highest mean values followed by the KCl materials. The gel, invert, and other waste types had values that were considerably lower and similar.

The Al (Table 15) and Fe (Table 17) mean values were highest for the Other waste type whereas Cr (Table 16) values were highest for the gel wastes. As indicated previously, the oil content (Table 18) values were considerably higher for the invert than the remaining waste types.

Appendix 4 provides statistical parameters for EC, Cl, Al, Cr, Fe, and oil content respectively for freshwater gel wastes in each of the ERCB regions. The values for EC and chloride were higher in region 3 than the remaining regions. It is interesting to note that the maximum value for EC in each of the regions exceeded the maximum acceptable level of 5 dS/m, whereas the maximum acceptable level of 700 mg/L for chloride was exceeded in all but regions 4 and 5.

Mean values for Al were highest in region 8 which was the only region to have a maximum value greater than the suggested level of 20 mg/L.

Mean values for Cr were all below the suggested maximum acceptable value of 1.0 mg/L; however maximum values for five of the eight regions exceeded the maximum acceptable value.

The mean values for Fe were all well below 20 mg/L for the regions however the maximum value reported for region 8 was in excess of the 20 mg/L. Similarly none of the regions had mean oil content levels in excess of the 5000 mg/L limit; however regions 3 and 10 had maximum levels in excess of the 5000 mg/L limit.

4.4.2 Solid Phase Data

The solid phase samples were analysed for several chemical and physical properties, soluble ions in saturated paste extracts, plant available trace elements (DTPA extractable), and total elemental content. As mentioned previously there are a broad range of approaches that can be utilized to interpret the data generated. This section of the report describes the statistical analysis of the data that was undertaken.

4.4.2.1 Chemical and physical properties. Statistical parameters relative to the chemical and physical properties of the solid phase samples (all samples representing all waste types) are provided in Table 19. Statistical parameters for the freshwater gel, invert, KCl, NaCl, and Other waste types are presented

Tables 13. Statistical Parameters for EC (dS/m) in the Different Liquid Phase Waste Types.

	Waste Type				
Parameter	Gel	Invert	KCl	NaCl	Other
Count (N)	157.00	35.00	60.00	9.00	20.00
Mean	3.40	3.53	16.33	39.36	3.63
Median	2.67	2.06	12.60	5.78	3.56
Std.Dev.	2.69	3.75	14.58	62.71	2.57
Maximum	13.40	15.30	54.80	149.00	10.70
Minimum	0.14	0.30	0.44	0.73	0.41

Table 14. Statistical Parameters for Cl (mg/L) in the Different Liquid Phase Waste Types.

	Waste Type				
Parameter	Gel	Invert	KCl	NaCl	Other
Count (N)	157.00	35.00	60.00	9.00	20.00
Mean	543.80	777.26	5441.61	40072.57	260.25
Median	157.00	590.00	3370.00	6620.00	109.00
Std. Dev.	1453.98	829.57	5646.51	53905.51	308.47
Maximum	9760.00	3550.00	20100.00	1170.00	1180.00
Minimum	5.21	37.30	29.00	76.00	27.10

Table 15. Statistical Parameters for Al (mg/L) in the Different Liquid Phase Waste Types.

	Waste Type				
Parameter	Gel	Invert	KCl	NaCl	Other
Count (N)	157.00	35.00	60.00	9.00	20.00
Mean	2.50	1.47	1.35	1.37	5.59
Median	1.00	1.20	0.89	1.29	0.86
Std.Dev.	10.28	1.13	1.47	1.28	15.11
Maximum	128.00	5.78	8.71	3.91	61.50
Minimum	0.10	0.10	0.10	0.10	0.10

Table 16. Statistical Parameters for Cr (mg/L) in the Different Liquid Phase Waste Types.

	Waste Type				
Parameter	Gel	Invert	KCl	NaCl	Other
Count (N)	157.00	35.00	60.00	9.00	20.00
Mean	0.21	0.02	0.06	0.01	0.02
Median	0.01	0.01	0.01	0.01	0.01
Std.Dev.	0.45	0.01	0.20	0.00	0.02
Maximum	3.59	0.03	1.36	0.01	0.07
Minimum	0.01	0.01	0.01	0.01	0.01

Table 17. Statistical Parameters for Fe (mg/L) in the Different Liquid Phase Waste Types.

	Waste Type				
Parameter	Gel	Invert	KCl	NaCl	Other
Count (N)	157.00	35.00	60.00	9.00	20.00
Mean	1.64	0.20	0.71	0.12	2.85
Median	0.79	0.04	0.09	0.01	0.95
Std.Dev.	3.67	0.68	3.46	0.33	5.19
Maximum	40.60	4.05	26.80	0.99	21.40
Minimum	0.01	0.01	0.01	0.01	0.01

Table 18. Statistical Parameters for Oil Content (mg/L) in the Different Liquid Phase Waste Types.

	Waste Type				
Parameter	Gel	Invert	KCl	NaCl	Other
Count (N)	62.00	17.00	23.00	4.00	9.00
Mean	534.42	10742.03	33.17	1.47	16.87
Median	2.88	661.00	2.00	1.56	1.50
Std.Dev.	3036.50	25920.95	143.06	0.90	45.45
Maximum	23300.00	106000.00	689.00	2.33	138.00
Minimum	0.33	1.11	0.44	0.44	0.44

Table 19. Statistical Parameters of the Chemical and Physical Properties for the Solid Phase Samples.

Parameter	H_2O	pH		TC	TOC	TIC	$CaCO_3$	ANC	Na	K	Ca	Mg	CEC
	(%)	H_2O	$CaCl_2$			(%)					(cmol(+)/kg)		
Count	651.00	651.00	651.00	651.00	651.00	651.00	651.00	122.00	122.00	122.00	122.00	122.00	122.00
Mean	144.75	8.72	8.66	4.50	3.32	1.19	9.89	15.59	21.64	8.30	37.58	1.85	20.61
Median	106.10	8.60	8.50	2.93	2.00	0.68	5.63	11.60	11.15	1.14	28.70	1.47	20.60
StDev	134.33	0.84	0.70	3.87	3.46	1.30	10.85	11.61	65.81	18.56	38.81	1.41	6.77
Maximum	990.00	12.50	12.40	27.00	24.80	9.61	80.10	58.90	697.00	104.00	304.00	11.70	37.30
Minimum	2.20	1.00	7.30	0.90	0.00	0.07	0.56	3.95	2.48	0.42	6.85	0.30	1.30

TC = Total Carbon; TIC = Inorganic Carbon; TOC = Total Organic Carbon; $CaCO_3$ = $CaCO_3$ Equivalent (g $CaCO_3$eq/ 100g soil); ANC = Acid Neutralizing Capacity; CEC = Cation Exchange Capacity.

Parameter	Oil	S	Si	C	EC50(%)	
		(%)			5 min	15 min
Count	122.00	122.00	122.00	122.00	651.00	651.00
Mean	1.28	30.65	41.82	27.53	57.16	55.63
Median	0.18	28.50	42.00	28.00	60.90	56.30
StDev	2.60	15.52	9.85	12.17	41.51	42.04
Maximum	11.80	88.00	82.00	62.00	100.00	100.00
Minimum	0.03	8.00	6.00	2.00	0.25	0.03

in Appendix 5. Statistical parameters for the physical and chemical properties of all the wastes by ERCB region and then individual waste types by ERCB region are provided in Appendix 30 of Volume II.

The mean values based on all samples were: pH(H_2O) - 8.72; total carbon - 4.5%; $CaCO_3$ equivalent - 9.89%; acid neutralizing capacity - 15.59% and; oil content - 1.28% (Table 19).

The mean pH values for the individual waste types were relatively similar with the lowest values recorded for the NaCl wastes. The mean oil contents ranged from 0.13% in the Other waste category to 6.22% in the invert waste with the remaining waste types having mean values of 0.5% or less.

4.4.2.2 Saturated paste extract properties. Statistical parameters relative to the saturated paste extract properties of the solid phase samples (all samples representing all waste types) are provided in Table 20. Statistical parameters for the freshwater gel, invert, KCl, NaCl and Other waste types are presented in Appendix 6. Appendix 31 of Volume II contains the statistical parameters for the saturated paste properties of all the wastes by ERCB region and then individual waste types by ERCB region.

A few of the more critical parameters including EC, Cl, and SAR were selected for further evaluation and discussion. Table 21 provides selected statistical parameters for EC in the different solid phase waste types. Mean EC values ranged from a low of 7.20 dS/m in the Other waste type to 92.53 dS/m in the NaCl waste. Appendix 7 provides selected statistical parameters for EC for samples from each of the different ERCB regions relative to the freshwater gel, invert, KCl, NaCl and Other waste types respectively.

The data in Appendix 7 indicate relatively similar mean values for EC in the freshwater gel wastes from the different regions. The differences between regions for the remaining individual waste types were somewhat broader.

Table 22 provides selected statistical parameters for Cl in the different solid phase waste types. Mean Cl values ranged from a low of 681 mg/L in the Other waste type and 1115 mg/L in the freshwater gel to 117 650 mg/L in the NaCl waste. Appendix 8 provides selected statistical parameters for Cl for samples from each of the different ERCB regions relative to the freshwater gel, invert, KCl, NaCl and Other waste types respectively.

Table 23 provides selected statistical parameters for SAR in the different solid phase waste types. Mean SAR values ranged from a low of 25.6 in the invert waste to 806 in the NaCl waste. Appendix 9 provides selected statistical parameters for SAR for samples from each of the different ERCB regions relative to the freshwater gel, invert, KCl, NaCl and Other waste types respectively.

4.4.2.3 DTPA extractable elements. The plant available fractions of the soil elements were estimated by DTPA extraction. The chelate extractable elements have been shown to correlate well with plant elements (Soltanpour and Workman 1981). Statistical parameters relative to the DTPA extractable elements (all samples representing all waste types) are provided in Table 24. Statistical parameters for the freshwater gel, invert,

Table 20. Statistical Parameters of the Saturated Paste Extract Data for the Solid Phase Samples.

Parameter	Satn	E.C.	pH	NO3	NH4	Alk.	HC03	C03	OH	Cl	Al	Cr
	(%)	(dS/m)		(mg/L)								
Count (N)	651.00	651.00	651.00	649.00	649.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00
Mean	82.39	18.16	8.16	29.42	1.26	324.57	262.45	47.82	14.30	7434.66	3.13	0.04
Median	72.50	8.38	7.90	0.55	0.50	186.00	174.00	1.49	0.04	725.00	1.95	0.01
StDev (sd)	40.61	25.21	0.92	174.08	2.73	515.30	354.55	208.00	140.25	21657.28	5.26	0.24
Maximum	640.00	162.00	12.70	2900.00	27.20	5790.00	3990.00	2990.00	2230.00	190000.00	38.80	4.23
Minimum	27.00	1.61	6.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.01

Sat'n = Percent Saturation; E.C. = Electrical Conductivity (dS/m); Alk = Alkalinity (mg CaCO3/L); HCO3, CO3, OH reported as mg CaCO3/L; SAR = Sodium Adsorption Ratio.

Parameter	Fe	V	Ti	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na	K
	(mg/L)											
Count (N)	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00
Mean	0.17	0.03	0.03	0.01	0.08	0.06	0.46	0.08	1160.56	30.72	3678.06	2662.79
Median	0.01	0.02	0.01	0.01	0.01	0.05	0.20	0.02	466.00	15.30	1880.00	74.10
StDev (sd)	1.50	0.07	0.17	0.08	0.32	0.08	5.25	0.30	2766.22	52.76	11410.52	9268.41
Maximum	24.40	1.12	4.09	1.97	4.28	1.84	134.00	6.03	23000.00	892.00	151000.00	84400.00
Minimum	0.01	0.02	0.01	0.01	0.01	0.05	0.01	0.00	0.50	0.05	98.80	7.66

Parameter	Li	Sr	B	Ba	P	Mo	Ni	Se	Co	S04	Si	As	SAR
	(mg/L)												
Count (N)	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00
Mean	0.11	15.35	0.63	0.32	0.54	0.63	0.06	0.15	0.01	1617.74	7.55	0.10	55.83
Median	0.06	4.53	0.37	0.07	0.11	0.48	0.02	0.15	0.01	1260.00	4.93	0.06	24.80
StDev (sd)	0.19	41.42	0.85	0.92	2.29	0.58	0.26	0.04	0.03	1371.05	8.32	0.13	156.40
Maximum	2.78	344.00	9.53	11.40	32.00	6.70	2.96	0.78	0.35	10800.00	67.20	1.23	2270.00
Minimum	0.02	0.00	0.02	0.00	0.05	0.03	0.02	0.15	0.01	23.30	0.05	0.02	0.85

Table 21. Statistical Parameters for Saturated Paste EC (dS/m) in the Different Solid Phase Waste Types.

	Waste Type				
Parameter	Gel	Invert	KCl	NaCl	Other
Count (N)	390.00	86.00	122.00	11.00	42.00
Mean	8.50	25.26	41.08	92.53	7.20
Median	7.13	19.25	30.15	127.00	6.94
Std. Dev.	6.81	17.43	36.22	62.78	2.76
Maximum	98.20	76.20	162.00	157.00	13.40
Minimum	1.65	1.61	2.04	5.15	2.77

Table 22. Statistical Parameters for Saturated Paste Cl (mg/L) in the Different Solid Phase Waste Types.

	Waste Type				
Parameter	Gel	Invert	KCl	NaCl	Other
Count (N)	390.00	86.00	122.00	11.00	42.00
Mean	1114.91	11599.88	17088.55	117651.36	680.74
Median	410.50	7755.00	10800.00	180000.00	532.50
Std. Dev.	3252.56	10551.44	20000.57	88822.68	685.98
Maximum	45400.00	44800.00	87500.00	190000.00	2970.00
Minimum	0.00	195.00	12.70	158.00	62.20

Table 23. Statistical Parameters for Saturated Paste SAR in the Different Solid Phase Waste Types.

	Waste Type				
Parameter	Gel	Invert	KCl	NaCl	Other
Count (N)	390.00	86.00	122.00	11.00	42.00
Mean	45.50	25.60	45.78	806.06	46.31
Median	27.40	11.05	22.70	1040.00	29.80
Std. Dev.	94.70	47.29	63.09	731.11	40.00
Maximum	1530.00	353.00	399.00	2270.00	173.00
Minimum	2.61	0.85	2.48	13.00	10.20

Table 24. Statistical Parameters of the DTPA-NH4HCO3 Extract Data for the Solid Phase Samples.

Parameter	Fe	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na	K	B	P
							(ug/g)					
Count (N)	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00
Mean	180.49	0.14	7.14	14.31	58.84	11.70	199.50	121.65	4803.35	2822.69	1.54	11.52
Median	170.00	0.13	6.50	10.00	16.00	10.50	195.00	97.80	2260.00	355.00	1.00	2.00
StDev (sd)	93.79	0.06	3.46	16.26	121.63	6.78	92.13	98.56	17096.08	7683.50	2.02	31.01
Maximum	615.00	0.75	30.80	270.00	895.00	52.00	868.80	915.00	206000.00	75200.00	17.30	354.00
Minimum	0.13	0.13	1.00	0.50	2.25	0.13	38.30	7.25	11.80	44.30	0.13	0.13

Parameter	Mo	Ni	Se
		(ug/g)	
Count (N)	651.00	651.00	651.00
Mean	0.68	2.04	0.54
Median	0.50	2.00	0.38
StDev (sd)	0.54	1.20	0.49
Maximum	3.50	8.50	6.50
Minimum	0.13	1.00	0.38

KCl, NaCl and Other waste types are presented in Appendix 10. Appendix 32 of Volume II contains the statistical parameters for the DTPA extractable elements for all the wastes by ERCB region and then individual waste types by ERCB region.

4.4.2.4 Total elemental analysis data. The total elemental analysis of the wastes is used to assess the potential for heavy metal and other trace element contamination. Statistical parameters relative to the total elemental content (all samples representing all waste types) are provided in Table 25. To begin the process of assessing any potential hazard to a receiving soil from the addition of wastes the mean values reported in Table 25 were compared to the values for total elemental content of soils presented in Table 26 (Lindsay 1979).

Comparing the mean values for the various elements in the wastes to the mean values in soils (Table 26) showed that values in the wastes were higher for Na, K, Mg, Cu, Zn, Mo, V, and Li. Furthermore, maximum values in the wastes were higher for Na, K, Mg, Cu, Zn, Ti, Ba, and Sr than the maximum values reported for soils in Table 26.

Statistical parameters for the freshwater gel, invert, KCl, NaCl and Other waste types are presented in Appendix 11. Appendix 33 of Volume II contains the statistical parameters for the total elemental analysis data for all wastes by ERCB region and then individual waste types by ERCB region.

The elements Cu, Cr, Ni, and Zn were chosen for further evaluation and discussion because their respective levels exceeded the selected maximum acceptable levels and/or they are found in drilling mud additives. For each of these elements highlighted in the following tables maximum acceptable concentration of the element in sewage sludge (Alberta Environment 1982) is provided. **THESE CONCENTRATION VALUES OR LIMITS ARE A MEANS FOR COMPARISON AND INTERPRETATION OF THE DATA AND ARE NOT RECOMMENDED VALUES.**

Table 27 provides selected statistical parameters for Cu in the different waste types. The mean values are similar for all waste types with the highest value recorded for the invert and the lowest value recorded for the NaCl waste types. Appendix 12 provides selected statistical parameters for Cu relative to each of the regions for each of the waste types. The extent of variation for mean values between regions was smallest for the invert waste.

Table 28 provides selected statistical parameters for Cr in the different waste types. The mean values were lowest in the invert, highest in the NaCl and almost equal for the freshwater gel, KCl and other waste types. Appendix 13 provides selected statistical parameters for Cr relative to each of the regions for each of the waste types.

Table 29 provides selected statistical parameters for Ni in the different waste types. Mean values were highest for the other waste type and lowest for the NaCl wastes with relatively similar mean values for the freshwater gel, invert and KCl wastes. Appendix 14 provides selected statistical parameters for Ni relative to each of the regions for each of the waste types. The extent of variation for mean values between regions was generally similar for each of the waste types.

Table 25. Statistical Parameters of the Total Elemental Analysis Data for the Solid Phase Samples.

Parameter	Mn	Na	K	Ca	Mg	Cu	Zn	P	Mo	Al	Fe
						(ug/g)					
Count (N)	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00
Mean	341.62	8548.30	17108.80	7330.21	5314.12	40.10	284.73	694.69	24.67	39985.55	26047.42
Median	331.00	7280.00	14600.00	6310.00	4420.00	35.90	131.00	633.00	25.20	44500.00	28100.00
StDev (sd)	114.28	13900.89	13647.08	5335.21	3571.36	17.69	585.88	871.76	14.89	21703.62	8489.26
Maximum	821.00	234000.00	143000.00	108000.00	35600.00	128.00	5530.00	21400.00	273.00	79800.00	49600.00
Minimum	45.80	55.50	1120.00	6.00	98.60	1.50	10.90	42.10	8.50	30.00	1170.00

Parameter	Ti	V	Cr	Ba	Ni	Sr	Li	Zr	Cd	Pb
					(ug/g)					
Count (N)	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00	651.00
Mean	2858.95	118.58	90.34	322.05	43.43	163.67	25.40	83.51	0.57	76.53
Median	3000.00	113.00	85.00	84.50	42.60	116.00	24.20	89.60	0.44	55.12
StDev (sd)	942.52	50.71	46.31	1572.58	17.88	273.93	15.30	32.13	0.60	117.94
Maximum	11200.00	433.00	433.00	23400.00	312.00	3110.00	71.80	157.00	6.12	2665.29
Minimum	185.00	4.50	10.60	5.73	4.50	7.92	7.00	4.50	0.06	1.00

Table 26. Elemental constituents of soils.

Element	Mean	Maximum	Minimum	Element	Mean	Maximum	Minimum
C (%)	2.00			Li (μg/g)	20.00	200.0	5.000
Ca (mg/g)	13.70	500.0	7.000	Cr (μg/g)	100.00	1000.0	1.000
Mg (mg/g)	5.00	6.0	0.600	Cu (μg/g)	30.00	100.0	2.000
Ti (mg/g)	4.00	10.0	1.000	Hg (μg/g)	0.03	0.3	0.010
Na (mg/g)	6.30	7.5	0.750	Ni (μg/g)	40.00	500.0	5.000
S (mg/g)	0.70	10.0	0.030	Pb (μg/g)	10.00	200.0	2.000
P (mg/g)	0.60	5.0	0.200	Co (μg/g)	8.00	40.0	1.000
Sr (mg/g)	0.20	1.0	0.050	Mo (μg/g)	2.00	5.0	0.200
Al (mg/g)	71.00	300.0	10.000	Cd (μg/g)	0.06	0.7	0.010
Si (mg/g)	320.00	350.0	230.000	Se (μg/g)	0.30	2.0	0.100
B (mg/g)	0.01	0.1	0.002	Ag (μg/g)	0.05	5.0	0.010
Ba (mg/g)	0.43	3.0	0.100	Zn (μg/g)	50.00	300.0	10.000
Fe (mg/g)	38.00	550.0	7.000	V (μg/g)	100.0	500.0	20.000
K (mg/g)	8.30	30.0	0.400	As (μg/g)	5.00	50.0	1.000
Mn (mg/g)	0.60	3.0	0.020	Zr (μg/g)	300.0	2000.0	60.0

From Lindsay (1979).

Table 27. Statistical Parameters for Total Elemental Cu (ug/g) in the Different Solid Phase Waste Types.

	Waste Type				
Parameter	Gel	Invert	KCl	NaCl	Other
Count (N)	390.00	86.00	122.00	11.00	42.00
Mean	40.30	46.31	37.14	21.37	39.00
Median	36.90	37.90	34.20	24.40	34.45
Std. Dev.	16.56	26.67	12.94	12.03	12.41
Maximum	128.00	121.00	97.50	37.90	68.40
Minimum	3.39	7.45	4.12	1.50	23.70

Table 28. Statistical Parameters for Total Elemental Cr (ug/g) in the Different Solid Phase Waste Types.

	Waste Type				
Parameter	Gel	Invert	KCl	NaCl	Other
Count (N)	390.00	86.00	122.00	11.00	42.00
Mean	94.49	60.51	90.29	162.66	94.00
Median	88.15	68.25	83.70	82.40	94.30
Std. Dev.	44.45	23.04	47.71	123.98	15.80
Maximum	433.00	110.00	347.00	316.00	127.00
Minimum	11.40	10.60	24.60	33.10	59.80

Table 29. Statistical Parameters for Total Elemental Ni (ug/g) in the Different Solid Phase Waste Types.

	Waste Type				
Parameter	Gel	Invert	KCl	NaCl	Other
Count (N)	390.00	86.00	122.00	11.00	42.00
Mean	44.76	36.84	43.15	24.51	50.30
Median	44.55	36.65	40.10	24.90	50.25
Std. Dev.	14.30	15.30	27.65	8.59	10.64
Maximum	91.60	78.00	312.00	39.70	72.30
Minimum	4.50	4.50	12.30	4.50	32.60

Table 30 provides selected statistical parameters for Zn in the different waste types. The mean values were lowest for the NaCl waste and highest for the invert waste. Appendix 15 provides selected statistical parameters for Zn relative to each of the regions for each of the waste types.

Table 30. Statistical Parameters for Total Elemental Zn (ug/g) in the Different Solid Phase Waste Types.

	Waste Type				
Parameter	Gel	Invert	KCl	NaCl	Other
Count (N)	390.00	86.00	122.00	11.00	42.00
Mean	281.59	476.02	222.81	92.58	152.40
Median	125.50	173.50	136.50	105.00	142.50
Std. Dev.	604.43	876.74	298.64	48.30	46.43
Maximum	5530.00	5120.00	2290.00	185.00	278.00
Minimum	10.90	53.30	64.80	32.20	92.40

4.5 DATA INTERPRETATION FOR LAND APPLICATION OF SOLID PHASE WASTES

The next step in the Drilling Waste Review Committees' utilization of the database established to support decision-making relative to criteria and guideline establishment involved calculation of the following for each sump sampled:

1. Waste application rate $\left(\frac{m^3 \text{ wet solids}}{ha}\right)$.
2. Area required for land application.
3. Limiting analyte(s).
4. Thickness of the applied waste layer (cm).

Table 31 provides a glossary of terms used in the calculation of waste application rates and areas required for disposal in this section of the report. The DWRC agreed to use the following assumptions for these calculations.

1. Only solid phase drilling wastes are to be considered for land application.
2. Mean values for each analyte are to be used for each sump.
3. The receiving soil has an electrical conductivity (EC) of 0.5 dS/m and a sodium adsorption ratio (SAR) of 1.
4. Limits regarding several analyte application rates $\left(\frac{kg\ i}{ha}\right)$ and the resultant EC, pH and SAR of the post application soil-waste mixture are described in Table 32.

4.5.1 Calculations

The following equations were used to calculate the application rates (R), areas required for application (A) and waste layer thickness (D). These were used for all of the solid waste analytes by substituting analyte values where appropriate.

i. The solid waste concentration of analyte i (except for Cl) obtained from the analytical laboratory as $C_{si}\left(\frac{mg\ i}{kg \text{ dry solids}}\right)$ is converted to another unit $\left(\frac{kg\ i}{kg \text{ dry solids}}\right)$ in the following manner:

$$C_{si}\left(\frac{kg\ i}{kg}\right) = C_{si}\left(\frac{mg\ i}{kg}\right) * 10^{-6}$$

Cl concentrations in the saturated paste extracts, obtained as $\left(\frac{mg\ Cl}{L}\right)$ from the analytical laboratory, are converted to $\left(\frac{kg\ Cl}{kg \text{ dry solids}}\right)$ using the saturation content of the saturated paste (P) in the following manner:

$$C_{Cl}\left(\frac{kg\ Cl}{kg}\right) = C_{Cl}\left(\frac{mg}{L}\right) * P\left(\frac{L}{kg}\right) * 10^{-6}$$

ii. The solid waste wet bulk density $\rho_{bw}\left(\frac{g \text{ dry solids}}{cm^3 \text{ wet solids}}\right)$ is converted to another unit $\left(\frac{kg \text{ dry solids}}{m^3 \text{ wet solids}}\right)$ in the following manner:

Table 31. Glossary of Terms Used in the Calculation of Waste Application Rates and Areas Required for Disposal.

EC = Electrical Conductivity measured in liquids or saturated paste extracts $\left(\frac{dS}{m}\right)$.

SAR = Sodium Adsorption Ratio, calculated from soluble Na, Ca, and Mg concentrations.

P = Saturation content of the saturated paste $\left(\frac{L}{kg\ dry\ solids}\right)$.

L_i = Regulatory limit for the application of wastes containing analyte i $\left(\frac{kg\ i}{ha}\right)$.

C_{si} = Concentration of analyte i in the solid waste material $\left(\frac{mg\ i}{kg\ dry\ solids}\right)$.

ρ_{bw} = Wet Bulk Density of the waste material $\left(\frac{kg\ dry\ solids}{m^3\ wet\ solids}\right)$.

R_{si} = Maximal Solid Waste Application Rate based on analyte i $\left(\frac{m^3\ wet\ solids}{ha}\right)$.

A_{si} = Minimal Allowable Area required to apply the solid waste material based on analyte i (ha).

D_{si} = Maximal Allowable Thickness of the applied solid waste material based on analyte i (cm).

V_s = Volume of the solid waste material (m^3 wet waste).

ρ_s = Specific density of the solid material $\left(\frac{g}{cm^3}\right)$.

ρ_w = Specific density of water $\left(\frac{g}{cm^3}\right)$.

ρ_o = Specific density of oil $\left(\frac{g}{cm^3}\right)$.

θ_m = Water content of the wet solid waste material $\left(\frac{kg\ water}{kg\ dry\ solids}\right)$.

θ_o = Oil content of the wet solid waste material $\left(\frac{kg\ oil}{kg\ dry\ solids}\right)$.

V_l = Volume of the liquid waste material (m^3).

C_{li} = Concentration of analyte i in the liquid waste material $\left(\frac{mg\ i}{L}\right)$.

R_{li} = Maximal Application Rate of liquid waste material based on analyte i $\left(\frac{m^3}{ha}\right)$.

A_{li} = Minimal Allowable Area required to apply the liquid waste material based on analyte i (ha).

D_{li} = Maximal Allowable Thickness of the applied liquid waste material based on analyte i (cm).

R_{sli} = Maximal Application Rate of solid plus liquid waste material based on analyte i $\left(\frac{m^3\ waste}{ha}\right)$.

A_{sli} = Minimal Allowable Area required to apply the solid plus liquid waste material based on analyte i (ha).

Table 32. Limits for the Land Application of Various Analytes.

Parameter	Limit $\left(\frac{kg}{ha}\right)$
Boron	10
Cadmium	1.5
Chloride	800
Chromium	100
Copper	200
Lead	100
Nickel	25
Nitrogen (NH_4+NO_3) - N	400
Sodium	500
Vanadium	50*
Zinc	300
Sodium	500
pH**	6.5 - 8.5
EC**	$4\ \frac{dS}{m}$
SAR**	10

* This value was later changed to 100.

** Based on predicted properties of the post application soil-waste mix.

$$\rho_{bw}\left(\frac{kg}{m^3}\right) = \rho_{bw}\left(\frac{g}{cm^3}\right) * 10^3$$

iii. The solid waste application rate based on analyte i (R_{si}) is calculated from the regulatory limit for i (L_i) and the waste characteristics C_{si} and ρ_{bw} as follows:

$$R_{si}\left(\frac{m^3}{ha}\right) = \frac{L_i\left(\frac{kg\ i}{ha}\right)}{C_{si}\left(\frac{kg\ i}{kg}\right) * \rho_{bw}\left(\frac{kg}{m^3}\right)}$$

iv. The area required for waste application based on waste component i (A_{si}(ha)) is calculated as:

$$A_{si}\ (ha) = \frac{V_s\ (m^3)}{R_{si}\left(\frac{m^3}{ha}\right)}$$

v. The thickness of the applied layer based on waste component i (D_{si} (cm wet waste)) is calculated as:

$$D_{si}\ (cm) = \frac{V_s\ (m^3)}{A_{si}\ (ha)} * 10^{-2}$$

or

$$D_{si}\ (cm) = R_{si}\left(\frac{m^3}{ha}\right) * 10^{-2}$$

Completing the calculations was complicated by the lack of the following:

1. Data for sludge wet bulk density $\rho_{bw}\left(\frac{kg\ dry\ solids}{m^3\ wet\ solids}\right)$.
2. Means to predict the resultant (limit) EC and SAR of the soil and waste mixture from the corresponding values for the individual soils and wastes considered.
3. A limit for oil. Since a limit was not set, two limits of 0.5% $\left(\frac{10\ 000\ kg\ oil}{ha}\right)$ and 1% $\left(\frac{20\ 000\ kg\ oil}{ha}\right)$ oil by soil-waste weight were used. It was deemed necessary to assess the role of oil present in wastes other than invert systems.

Four scenarios were developed to take into account the above limitations. Calculations for the four scenarios follow. To initiate the process, mean values for selected properties of the drilling waste solid samples were calculated and reported in Appendix 16.

4.5.1.1 Scenario 1. In this scenario it was assumed that the ρ_{bw} for all the wastes was 1.3 $\left(\frac{g\ dry\ solids}{cm^3\ wet\ solids}\right)$. This value was obtained as the mean ρ_{bw} of 31 drilling waste samples that were rewetted to their original water content and their wet bulk volumes measured. In the drilling waste data set, gravimetric water contents (θ_m) for all solid samples in all sumps were reported, and these values were used to rewet the 31 samples mentioned previously.

It was also assumed that one could use sodium application rates as a surrogate for both EC and SAR calculations. The addition of slaughterhouse wastewater to an Alberta medium textured soil increased soil EC by 1.5 dS/m and SAR by 2.5 for each 200 kg Na/ha addition (Alberta Environment, 1987). If one accepts the above, then the increase in soil EC from 0.5 (pre application) to 4 dS/m (limit after application) corresponds to a sodium application rate of approximately 500 kg Na/ha. The corresponding increase in SAR from 1 to 10 (pre to post application) is equivalent to 720 kg Na/ha. A sodium limit of 500 kg Na/ha was chosen as a surrogate for EC and SAR calculations.

Results of the calculations for scenario 1 are not included in this report, however they are on file with the authors.

4.5.1.2 Scenario 2. This scenario is similar to scenario 1 except that the wet bulk density is calculated from the water content, oil content and an assumed solids density of 2.6 g/cm^3. The equation for the wet bulk density (ρ_{bw}) was developed as follows (assuming that the samples' pore spaces are water and/or oil saturated):

$$\rho_{bw} = \frac{M_s + M_o}{V_s + V_w + V_o}$$

Where M_s and V_s are the weight and volume of the solids,

M_w and V_w are the weight and volume of the water, and

M_o and V_o are the weight and volume of the oil.

Furthermore, the solids density (ρ_s), water density (ρ_w), oil density (ρ_o), water (θ_m) and oil (θ_o) contents are defined as:

$$\rho_s = \left(\frac{M_s}{V_s}\right) = 2.6\ \frac{g}{cm^3}$$

$$\rho_w = \left(\frac{M_w}{V_w}\right) = 1\ \frac{g}{cm^3}$$

$$\rho_o = \left(\frac{M_o}{V_o}\right) = 0.9\ \frac{g}{cm^3},$$

and

$$\theta_m = \left(\frac{M_w}{M_s}\right),\ \theta_o = \left(\frac{M_o}{M_s}\right)$$

Substituting the above into the ρ_{bw} equation leads to the following equation for ρ_{bw}:

$$\rho_{bw} = \left(\frac{1 + \theta_o}{\theta_w + \left(\frac{1}{\rho_s} \right) + \left(\frac{\theta_o}{\rho_o} \right)} \right), \text{ or}$$

$$\rho_{bw} = \left(\frac{1 + \theta_o}{\theta_w + \left(\frac{1}{2.6} \right) + \left(\frac{\theta_o}{0.9} \right)} \right)$$

Therefore one requires only the water and oil contents (measured for all solid waste samples) in order to calculate the wet bulk density.

Results of the calculations for scenario 2 are not included in this report, however they are on file with the authors.

4.5.1.3 Scenario 3. This scenario assumes the same wet bulk density as scenario 2, but uses a procedure for calculating rates and areas based on the EC and SAR values instead of the Na limits used previously.

In this scenario it is assumed that one can calculate the resultant EC and SAR values for soil-waste mixtures from the EC and SAR values of the individual components (soils and wastes). This 'mixture' model assumes that the contribution of each component to the mix is proportional to its intrinsic value (EC or SAR) and its weight in the mix. In this model one creates two equations with two unknowns (weight of waste and soil in the mix) each and solves them for the desired unknown (e.g. weight of waste in the mix, or application rate). EC is used as an example to illustrate this calculation.

First, it is assumed that a hectare furrow slice of soil-waste mix is proportionally made up of X amount of waste and Y amount of soil, such that:

$$X + Y = 1$$

Where

$$X = \left(\frac{\text{waste weight (kg)}}{\text{ha soil-waste mix (kg)}} \right)$$

or

$$X = \left(\frac{\text{waste weight (kg)}}{2x10^6 \text{ kg}} \right)$$

Y is similarly defined for soil.

Secondly, it is assumed that the resultant EC (EC_c) of the soil-waste mix can be calculated from the soil EC (EC_s) and waste EC (EC_w) as follows:

$$EC_c = X * EC_w + Y * EC_s$$

Solving the above two equations for X_{EC} (i.e. X based on EC values) results in:

$$X_{EC} = \frac{EC_c - EC_s}{EC_w - EC_s}$$

and similarly for SAR, one obtains:

$$X_{SAR} = \frac{SAR_c - SAR_s}{SAR_w - SAR_s}$$

Limits for EC_c and SAR_c were 4 dS/m and 10 respectively, and EC_s and SAR_s were assumed as 0.5 dS/m and 1. Therefore, X_{EC} and X_{SAR} can be calculated from the EC and SAR values of the waste samples only. The application rates (R_{EC} and R_{SAR}), areas required (A_{EC} and A_{SAR}) and waste layer thicknesses (D_{EC} and D_{SAR}) can be calculated from the X values (for both EC and SAR limits) as follows:

$$R\left(\frac{m^3}{ha}\right) = \frac{X\left(\frac{kg}{kg}\right) * \left(\frac{2x10^6\ kg}{ha}\right)}{\rho_{bw}\left(\frac{kg}{m^3}\right)}$$

$$A\ (ha) = \left(\frac{V_s\ (m^3\ wet\ solids)}{R\left(\frac{m^3\ wet\ solids}{ha}\right)}\right)$$

$$D\ (cm) = \left(\frac{V_s\ (m^3)}{A\ (ha)}\right) x\ 10^{-2}$$

The calculations for this scenario are not included in this report, however they are on file with the authors.

4.5.1.4 Scenario 4. The calculations for this scenario are similar to those of scenario 3 with the exception that the calculated EC and SAR values for the soil-waste mix were slightly modified as described below.

In scenario 3 it was assumed that the calculated EC_c and SAR_c values for the soil-waste mix are similar to the measured values after waste application and mixing (EC_m and SAR_m), or:

$$\mathbf{EC_m = EC_c, \text{ and } SAR_m = SAR_c}$$

Linear equations for EC_m vs EC_c and SAR_m vs SAR_c were calculated using the soil, waste, and soil-waste mix EC and SAR data for three greenhouse studies of drilling wastes impacts on Alberta soils reported by Macyk et al. (1989) . These equations were forced through the origin (i.e. calculated and mixture values are both 0 at the same time), and were found to be (Figures 4 and 5):

$$EC_m = 1.8EC_c, and\ SAR_m = 1.3SAR_c$$

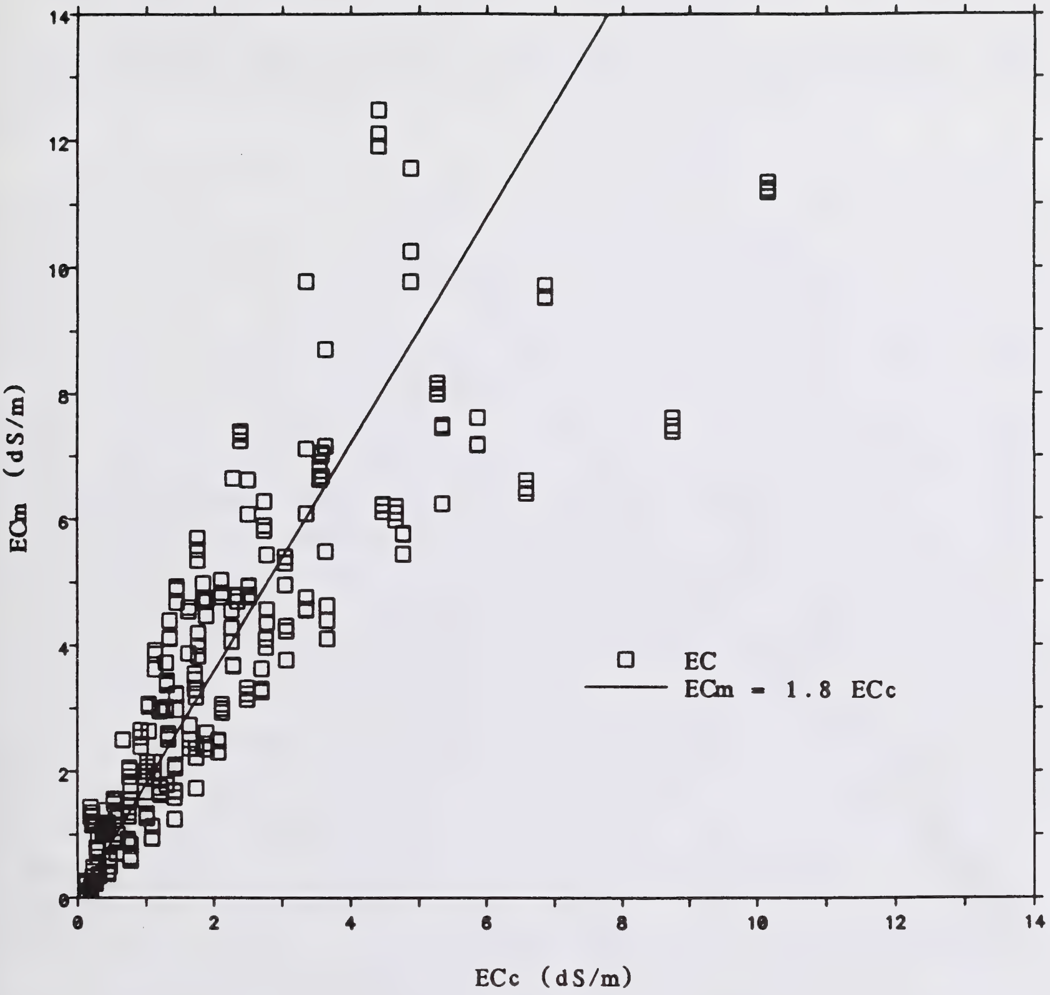


Figure 4. Measured vs Calculated EC for Three Pot Trial Soils.

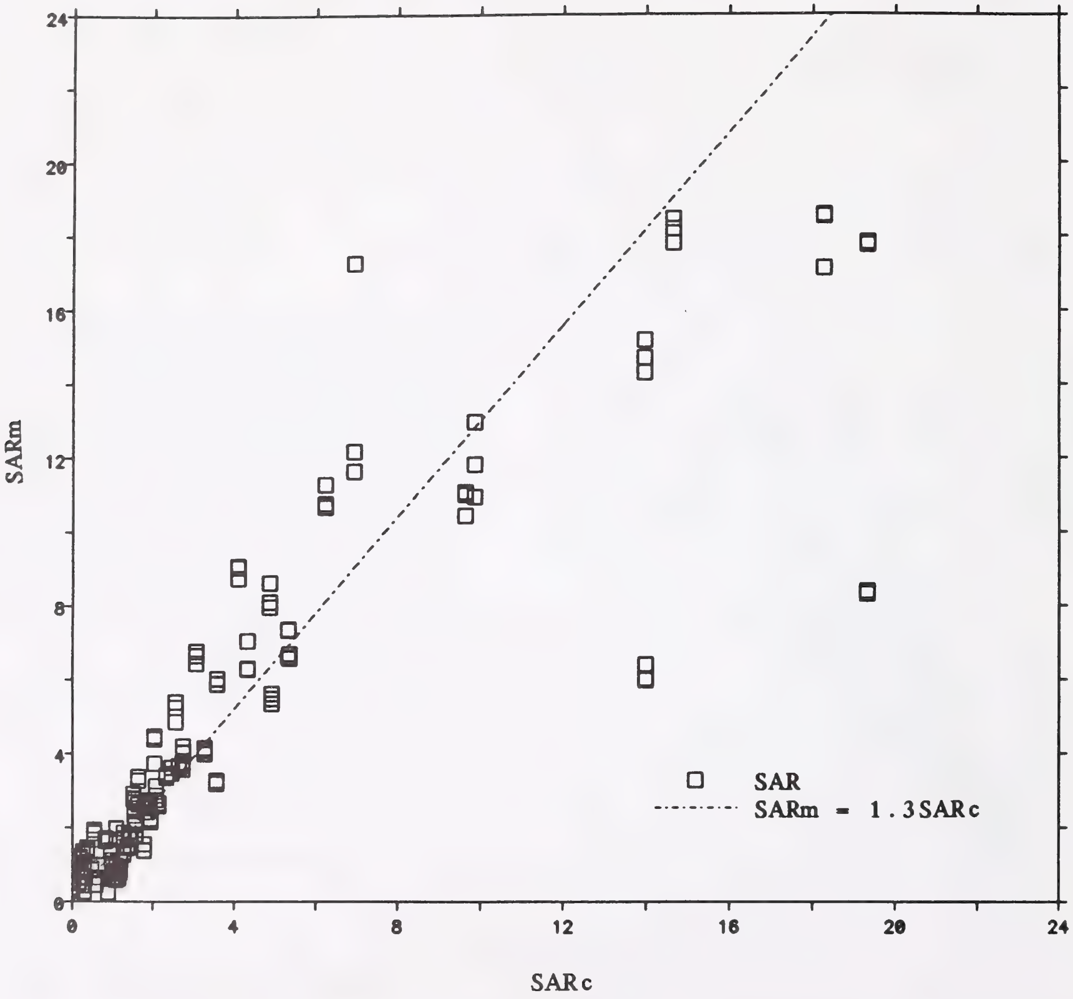


Figure 5. Measured vs Calculated SAR for Three Pot Trial Soils.

Therefore, for the limit EC_m of 4 dS/m, the EC_c is 2.22 dS/m. Similarly, for the limit SAR_m of 10, the SAR_c is 7.69.

The new EC_c and SAR_c values were used as in scenario 3 to calculate the application rates, areas required and layer thickness based on EC and SAR limits.

The calculations for this scenario are reported in Appendices 17 to 20. Appendix 17 provides application rates in $\left(\frac{m^3\ wet\ solids}{ha}\right)$ for the solid phase wastes from each sump location.

Appendix 18 provides the area required for land application of the solid wastes on the basis of selected parameters for each sump. Appendix 19 provides the limiting analytes requiring >1 ha for land application and Appendix 20 the thickness of the solid phase waste layer application.

Table 33 provides a summary of the limiting sump parameters on the basis of number of sumps out of a total of 113 sumps evaluated. EC, Na and Cl were each limiting for about 30% of the sumps. The most limiting analyte was Cl, followed by Na (or SAR where Na is not considered) and EC. Oil was limiting in <2% of the sumps and the only metals showing any limitations were Zn, Pb and V (at a limit of 50 kg/ha only).

Table 34 provides a summary of the number of sumps having specific limiting analytes requiring > 1 ha for land application of the solid waste. The summary is organized on the basis of waste type. Salt based muds KCl (55%) and NaCl (100%)) predictably showed the highest proportional number of sumps requiring > 1 ha for disposal, followed by invert (44%) and gel (20%) based muds. Oil was limiting for some KCl (4%) and gel (5%) based muds, but was most limiting for the invert samples (44%). Metals (Cu, Zn, Cr, Ni, Cd, and Pb) were limiting for gel (9%), invert (11%), and KCl (11%) sumps only. Vanadium (at a limit of 50 kg/ha) was limiting for 30% of the gel, 18% of the KCl, and 11% of the invert sumps.

The above data indicate that limitations to land application of the drilling waste solids were predominantly due to the presence of salts, followed by oil and metal contents. The gel sumps showed the least proportional limitations of the sumps studied.

4.6 DATA INTERPRETATION FOR LAND APPLICATION OF LIQUID PHASE WASTES.

4.6.1 Calculations

The following equations were used to calculate liquid waste application rates (R_{li}), areas required (A_{li}) for application and the depth (thickness, D_{li}) of the waste layer that could be applied using the liquid phase volume (V_l), analyte concentrations (C_{li}) and its associated regulatory limit (L_i). For EC and SAR calculations, an approach similar to that of the solids (scenario 4) was used. These calculations should be considered as a worst case scenario because of the omission of allowing for a portion of the liquid that will leach from the plow layer considered.

$$R_{li}\left(\frac{m^3}{ha}\right)=\frac{L_i\left(\frac{kg\ i}{ha}\right)*10^3}{C_{li}\left(\frac{mg\ i}{L}\right)}$$

Table 33. Summary* of Limiting Parameters for Sumps Requiring > 1 ha for Disposal of Solid Wastes.

Limiting Parameter	Number of Sumps	Most Limiting (Number of Sumps)	
		Na Not Considered	Na Considered
EC	37	8	6
SAR	17	10	3
Cl	31	21	19
Na	37	0	17
NH_4 &NO_3-N	0	0	0
Oil (10000)	12	2	2
Oil (20000)	8	2	2
Cu	1	0	0
Zn	4	1	0
V	26	7(0)**	3(0)**
Cr	3	0	0
Ni	11	0	0
Cd	2	0	0
Pb	5	1	0

* Summarized from Appendix 20.

** A total of 7 or 3 sumps would be most limited by the limit of 50 kg V/ha. Raising the limit to 100 kg V/ha results in 0 sumps limited by V.

Table 34. Number of Sumps With Limiting Analytes Requiring >1 ha Area for Land Application of Solid Wastes Relative to Waste Type.

Limiting	Waste Type				
Analyte	Gel (64)*	Invert (18)	KCl (22)	NaCl (1)	Other (8)
EC	13	8	15	1	0
SAR	11	1	3	1	1
Cl	7	8	15	1	0
Na	22	5	9	1	0
NH_4 &NO_3-N	0	0	0	0	0
Oil (10 000)	3	8	1	0	0
Oil (20 000)	3	5	0	0	0
Cu	1	0	0	0	0
Zn	2	1	1	0	0
V**	19	2	5	0	0
Cr	3	0	0	0	0
Ni	6	2	3	0	0
Cd	2	0	0	0	0
Pb	3	2	0	0	0

* The numbers following the sump type indicate the number of sumps of each type where data were available.

** Based on a limiting value of 50 kg V/ha.

$$A_{li}\ (ha) = \left(\frac{V_l\ (m^3)}{A_{li}\left(\frac{m^3}{ha}\right)} \right)$$

$$D_{li}\ (cm) = A_{li}\left(\frac{m^3}{ha}\right)\ x\ 10^{-2}$$

To provide the basis for the calculations, mean values for selected properties of the drilling waste liquid samples were calculated and reported in Appendix 21.

Appendix 22 provides application rates in m^3 for the liquid phase wastes from each sump location. Appendix 23 provides the area required for land application of the liquid phase wastes on the basis of selected parameters for each sump. Appendix 24 provides the limiting analytes requiring >1 ha for land application of the liquid phase wastes. Appendix 25 provides values for the thickness (cm) of the drilling waste layer applied relative to the disposal from each sump.

Table 35 provides a summary of the limiting liquid sump parameters on the basis of number of sumps out of a total of 113 sumps evaluated. The data indicate that the limiting analytes were primarily SAR and Cl, with oil content and EC being limiting for only two sumps. Metals were not considered in these calculations as the assessment of their concentrations showed that they are not a concern in the liquid phase samples.

4.7 LAND APPLICATION OF SOLID AND LIQUID PHASE WASTES COMBINED

4.7.1 Calculations

The following equations were used to calculate the potential application rates (R_{sli}) and areas required for application (A_{sli}) of the mixed liquid and solid phase wastes from each sump location.

The concentration of an element i (C_{sli}) in a drilling waste (mixed solids and liquids) is calculated from the concentration of i in the solid (C_{si}) and liquid (C_{li}) phases and the volumes of these two phases (V_s and V_l). The application rates (of the combined solid and liquid phases) based on EC and SAR values were calculated as the weighted (based on volume contribution) mean of the application rates of the solid and liquid phases calculated previously.

$$C_{sli}\left(\frac{kg\ i}{m^3}\right) = \left(\frac{\left(C_s\left(\frac{kg\ i}{kg}\right) x \rho_{bw}\left(\frac{kg}{m^3}\right) x V_s\ (m^3)\right) + \left(C_{li}\left(\frac{mg\ i}{L}\right) x V_l\ (m^3)\right)}{(V_s\ (m^3) + V_l\ (m^3)) * 10^9} \right)$$

Application Rates (R_{sli}) were calculated as follows:

$$R_{sli}\left(\frac{m^3}{ha}\right) = \left(\frac{L_i\left(\frac{kg\ i}{ha}\right)}{C_{sli}\left(\frac{kg\ i}{m^3}\right)} \right)$$

and areas (A_{sli}) as:

$$\boldsymbol{A_{sll}}\ (ha) = \left(\frac{(\boldsymbol{V_s} + \boldsymbol{V_l})\ (m^3)}{\boldsymbol{R_{sll}} \left(\frac{m^3}{ha} \right)} \right)$$

Appendix 26 provides the potential application rates for the combined solids and liquid wastes for each sump based on the specific characteristics of the wastes contained therein. Appendix 27 provides the area (ha) required for landspreading of the combined solid and liquid phase wastes at each of the sump locations. This is followed by Appendix 28 which provides the limiting analytes requiring >1 ha for the application of both the solid and liquid wastes at each of the sump locations.

Table 36 provides a summary of the limiting sump parameters (solid and liquid phases) on the basis of number of sumps out of a total of 113 sumps evaluated. Na, SAR, EC and Cl were limiting for 62, 46, 51, and 38 sumps respectively. The most limiting analytes were SAR, followed by Cl and EC (Na not considered) and Na, Cl, SAR and EC (Na considered). Oil was limiting in 4 sumps at a limit of 10 000 kg/ha. Metals showing limitations were Cu, Zn, V, Cr, Ni, Cd, and Pb. The most limiting metal analytes were either Zn or V (at a limit of 50 kg/ha only).

Table 35. Summary* of Limiting Parameters for Sumps Requiring > 1 ha for Disposal of Liquid Wastes.

Limiting Parameter	Number of Sumps	Most Limiting (Number of Sumps)	
		Na Not Considered	Na Considered
EC	28	2	1
SAR	31	26	21
Cl	17	15	14
Na	31	0	8
NH_4 &NO_3-N	0	0	0
Oil (10000)	2	2	2
Oil (20000)	1	0	0

* Summarized from Appendix 21.

Table 36. Summary* of limiting parameters for sumps requiring > 1 ha for disposal of liquid and solid wastes combined for each sump.

Limiting Parameter	Number of Sumps	Most Limiting (Number of Sumps)	
		Na Not Considered	Na Considered
EC	51	12	7
SAR	46	31	16
Cl	38	24	23
Na	62	0	25
NH_4 &NO_3-N	0	0	0
Oil (10000)	13	4	4
Oil (20000)	8	0	0
Cu	1	0	0
Zn	4	1	1
V	26	2(0)**	5(0)**
Cr	3	0	0
Ni	12	0	0
Cd	2	0	0
Pb	5	0	0

* Summarized from Appendix 28.

** A total of 5 or 2 sumps would be most limited by the limit of 50 kg V/ha. Raising the limit to 100 kg V/ha results in 0 sumps limited by V.

5. SUMMARY

5.1 SAMPLING

The ARC was the overall manager of the sampling program with a coordinator and two three-man sampling crews from Nor-Chief Consulting Services (1978) Ltd. of Calgary. A total of 87 oil and gas companies, 17 mud companies, government agencies, contractors and consulting firms were contacted during the sump selection process. All sampling, sample handling and transport methods were conducted in accordance with the study design specifications.

The sampling program began June 5, 1990 and concluded on October 19, 1990 with about 90% of the sampling being completed by August 3, 1990. A sampling demonstration was conducted at a sump location in the Innisfail area on October 16, 1990 with representatives of the private and public sectors in attendance.

Approximately 50% of the sumps sampled resulted from the previous winter drilling program with the remainder representing sampling shortly after rig release. The sampling program involved the collection of samples from 128 individual sumps located at 114 different geographic locations. These included 72 freshwater gel, 19 invert, 27 KCl, 2 NaCl, and 8 Other waste type sumps. A total of 288 liquid phase, 653 solid phase, 9 QA/QC, and 30 source water samples were obtained.

5.2 WELL DEPTH AND MUD VOLUME

Information regarding well depth relative to the sumps sampled was provided by the respective companies and by the ERCB. The data indicated that 23% of the wells had depths equal to or less than 1000 m, 33% had depths greater than 1000 m and less than or equal to 2000 m and 22% had depths greater than 2000 m and less than or equal to 3000 m.

Mud volume was estimated from the measurements taken by the field crews at the time of sampling. Approximately 75% of the sumps sampled had a mud volume less than or equal to 1000 m^3 or about 6000 barrels. The largest mud volumes occurred at well locations west of the 6th meridian.

5.3 ANALYTICAL RESULTS

The analytical work was completed according to the study design of Macyk and Abboud (1990). The data pertinent to the various analyses for the liquid and solid phase samples were submitted to the members of the Drilling Waste Review Committee as they became available. Statistical analysis was undertaken to summarize the data in a systematic manner with most of the tables provided in Volume II.

Two approaches were taken to synthesize or reduce the volume of data that was generated. First of all, comparisons of values for selected parameters or analytes relative to waste type and/or ERCB region were made. Secondly, values for selected parameters or analytes were compared to existing water or soil quality guidelines.

5.3.1 Liquid Phase Data

The liquid phase data were compared to guidelines for irrigation water quality prepared by the Task Force on Water Quality Guidelines of the Canadian Council of Resource and Environment Ministers (CCREM 1987). In completing this comparison it became apparent that the parameters which exceeded the existing and/or selected guidelines were EC, Cl, Al, Cr, Fe, and oil content.

For all liquid samples the EC values ranged from 0.14 to 149 dS/m with a mean of 7.34 dS/m. The maximum tolerable level for irrigation water is about 5 dS/m. The Cl values ranged from 5.21 to 117 000 mg/L with a mean value of 2865 mg/L whereas the maximum acceptable level for irrigation water is 700 mg/L.

Oil content in the liquid phase waste samples ranged from 0.33 to 106 000 mg/L with a mean value of 1884 mg/L.

Tables were prepared to provide a comparison of EC, Cl, Al, Cr, Fe and oil content respectively for the gel, KCl, NaCl, invert, and Other waste types for the entire province.

5.3.2 Solid Phase Data

The solid phase samples were analysed for several chemical and physical properties, soluble ions in saturated paste extracts, plant available trace elements (DTPA extractable), and total elemental content.

5.3.2.1 Chemical and physical properties. Statistical parameters relative to the chemical and physical properties of the solid phase samples were provided. The mean values based on all samples were: pH (H_2O) - 8.72; total carbon (TC) - 4.5%; $CaCO_3$ equivalent - 9.89%; acid neutralizing capacity (ANC) - 15.59% and; oil content - 1.28%.

The mean pH values for the individual waste types were relatively similar with the lowest values recorded for the NaCl wastes. The mean oil contents ranged from 0.13% in the Other waste category to 6.22% in the invert waste with the remaining waste types having mean values of 0.5% or less.

5.3.2.2 Saturated paste extract properties. Statistical parameters relative to the saturated paste extract properties were provided and EC, Cl, and SAR were selected for further evaluation and discussion. Mean EC values ranged from a low of 7.20 dS/m in the Other waste type to 92.53 dS/m in the NaCl waste. Mean values for EC in the freshwater gel wastes from the different regions were relatively similar, however the differences between regions for the remaining individual waste types were somewhat broader. Mean Cl values ranged from a low of 618 mg/L in the Other waste type and 1115 mg/L in the freshwater gel to 117 650 mg/L in the NaCl waste.

5.3.2.4 Total elemental analysis data. Comparing the mean values for the various elements in the wastes to the mean values in soils showed that values in the wastes were higher for Na, K, Mg, Cu, Zn, Mo, V, and Li. The elements Cu, Cr, Ni and Zn were selected for further evaluation and discussion since they exceeded levels generally found in soils and/or are commonly found in drilling mud additives.

5.4 DATA INTERPRETATION

Utilization of the database established to support decision-making relative to criteria and guideline establishment involved a number of calculations relative to the liquid and solid phase components of each sump sampled.

5.4.1 Solid Phase Wastes

Calculations relative to the solid phase wastes from each sump included waste application rate (m^3 wet waste/ha), area required for land application (ha), limiting analyte(s), and thickness of the applied waste layer (cm). Limits for land application of various analytes were developed by the DWRC and four scenarios were defined for completion of the calculations.

5.4.2 Liquid Phase Wastes

Calculations regarding liquid waste application rates, areas required for application, and the depth (thickness) of the waste layer that could be applied were completed. The results indicated that the limiting analytes were primarily Cl, Na, EC, and SAR.

5.4.3 Solid and Liquid Phase Wastes Combined

Calculations to determine the potential application rates and areas required for application of both the liquid and solid phase wastes from each sump location were completed. Overall EC, Cl, Na, and SAR were the most limiting analytes.

6. CONCLUSIONS

The objective of this project was to characterize drilling wastes from throughout Alberta. The information obtained provided a database in support of updating existing drilling waste guidelines by the Drilling Waste Review Committee.

Therefore, this report provides a summary and discussion relative to the data obtained from the sumps sampled in 1990 and draws few conclusions. The conclusions presented are intended to highlight general areas that the Drilling Waste Review Committee might consider in its work to revise existing guidelines:

1. In liquid phase drilling wastes the parameters or analytes considered limiting included Cl, Na, EC, and SAR.
2. In solid phase drilling wastes the parameters or analytes considered limiting included EC, Cl, Na, SAR, and to a lesser extent oil content and some trace elements (Cu, Cd, Cr, Ni, Pb, V, Zn).

7. REFERENCES

Alberta Environment, 1982. Guidelines for the application of municipal wastewater sludges to agricultural lands. Standards and Approvals Division and Earth Sciences Division. 26 pp.

Alberta Environment, 1987. Guidelines for land application of wastewater from slaughter and packing plants. Alberta Environmental Protection Services. 8 pp.

AOAC, 1981. Official methods of analysis. Fourteenth edition, Association of Official Analytical Chemists, Arlington, Virginia.

APHA (American Public Health Association), 1980. Standard Methods for the Examination of Water and Wastewater. 15th Edition. Publication Office: American Public Health Association 1015. Fifteenth Street NW, Washington, DC 20005. ISBN 0-87553-091-5.

Bascomb, C.L., 1961. A calcimeter for routine use on soil samples. Chemistry and Industry (Part II):1826-1827.

CCREM, 1987. Canadian water quality guidelines. Canadian Council of Resource and Environment Ministers, Ottawa, Ontario.

Doughty, J.L., 1941. The advantages of a soil paste for routine pH determination. Soil Science 22:135-138.

Environment Canada, 1980. Standard procedure for testing the acute lethality of liquid effluents. Water Pollution Control Directorate, Environmental Protection Service, Environment Canada. Report No. EPS1-WP-80-1.

EPA, 1983. Methods for chemical analysis and wastes. Environmental Monitoring and Support Laboratory, Cincinnati, Ohio. EPA-600/4-79-020.

ERCB, 1975. Interim Directive. ID-OG 75-2: Sump Fluid Disposal Requirements. Energy Resources Conservation Board, Calgary, Alberta.

Gee, G.W. and J.W. Bauder, 1979. Particle size analysis by hydrometer: A simplified method for routine textural analysis and a sensitivity test of measurement parameters. Soil Science Society of America Journal 43:1004-1007.

Holmgren, G.G.S., R.L. Juve, and R.C. Geschwender, 1977. A mechanically controlled variable rate leaching device. Soil Science Society of America Journal 32:568-570.

Leco Corporation, 1979. CR-12 carbon system 781-600. Instrument Manual 200-195.

Lindsay, W.L., 1979. Chemical equilibria in soils. John Wiley and Sons, New York.

Macyk, T.M. and S.A. Abboud, 1990. Drilling waste sump chemistry study design. Alberta Research Council, Terrain Sciences Department report prepared for the Drilling Waste Review Committee and the Alberta Land Conservation and Reclamation Council, Reclamation Research Technical Advisory Committee.

Macyk, T.M., F.I. Nikiforuk, S.A. Abboud and Z.W. Widtman, 1989. Detailed sampling, characterization and greenhouse pot trials relative to drilling wastes in Alberta. Alberta Land Conservation and Reclamation Council Report No. RRTAC 89-6. 228 pp.

Matthews, J.E. and L. Hastings, 1987. Evaluation of toxicity test procedure for screening treatability potential of waste in soil. Toxicity Assessment: An International Quarterly Vol. 2, 265-281.

McGill, W.B. and M.J. Rowell, 1977. Extraction of oil from soils. Chapter 4. IN: "The Reclamation of Agricultural Soils After Oil Spills, Part I: Research", edited by J.A. Toogood. AIP Publication M-77-11, University of Alberta, Edmonton.

Peech, M., 1965. Hydrogen-ion activity. IN: 'Methods of Soil Analysis, Part 2', C.A. Black et al. (ed.). Agronomy 9:914-926. American Society of Agronomy, Inc., Madison, Wisconsin.

Soltanpour, P.N. and S.M. Workman, 1981. Soil-testing methods used at Colorado State University soil testing laboratory. Colorado State University.

USDA, 1954. Diagnosis and improvement of saline and sodic soils. Agriculture Handbook 60, United States Department of Agriculture. 160 pp.

APPENDIX 1.

LIST OF SAMPLING CONTACTS

OIL AND GAS COMPANIES CONTACTED

AEC
Altana
Altex
American Eagle
Amoco
Anderson
Atcor
Atlantis
Barons
Bow Valley Inc.
BP Resources
Bralone
Brinkerhoff
Bumper
Cabre
Can-Hunter
Cdn-Oxy
Cdn-Roxy
Chauvco
Chevron
Cimmarron
CNRL
CNWE
Chesapeake
Coachwood Res.
Co-enerco
Coho
Colin
Columbia
Conoco
Coseka
Dekalb
Encor
Enron
Esso
Forest
Gascan
Glen-crest
Glen-Isle
Gulf
Harbour
Home
Husky
Inverness
Keles
Ladd
Lasmo
Mark
Mobil
Morgan
Murphy
N.C.O.
Norcen
Northridge
Northstar
Novalta
Nugas
Omega
OMV
Olympia
Pacific
Paloma
PanCanadian
PennWest
Petro-Canada
Petro Rep
Phillips
Pinnacle
Place Res
Placid
Ranchmens
Renaissance
Rife
Ryerson
Shaman Energy
Sceptre
Saskoil
Shell
Summitt
Suncor
Total
Trilogy
Ulster
Union Pacific
Unocal
Voyager
Westcoast

GOVERNMENT AGENCIES CONTACTED

ALBERTA FOREST SERVICE OFFICES:

Bow/Crow
Fox Creek
High Level
Hines Creek
Hinton
Manning
Peace River
Rainbow Lake
Red Earth
Robb
Slave Lake
Whitecourt

ERCB OFFICES

Drayton Valley
Grande Prairie
Medicine Hat
Red Deer
Wainwright

PUBLIC LANDS OFFICES

Grande Prairie

MUD COMPANIES CONTACTED

Alpha
Baroid
Bio-Tech
Canadian Fluids Mission
International
Concorde
Dynamil

I.D.F.
M-1
Mil-Park
Welltec
Mudco
Pinnacle

Protec
Reef
Techni Fluids

CONTRACTORS AND CONSULTING COMPANIES CONTACTED

Contractors:

Caskey
D. Clark Construction
D.B. King Construction
Dechant Construction
Independent Environmental
Kidd Construction

Krause Construction
Lindsey Construction
S.T.A.D.
W.O.E.S.
Zell Oilfield

Consultants:

Bissett Resources Mega Engineering
Burrell Consulting

Walley Maney
Nor-Chief Consulting

APPENDIX 2. WELL DEPTHS AND MUD VOLUMES

- WELL DEPTHS AND MUD VOLUMES (ALL LOCATIONS).
- WELL DEPTHS AND MUD VOLUMES FOR LOCATIONS W4 MERIDIAN.
- WELLS DEPTHS AND MUD VOLUMES FOR LOCATIONS W5 MERIDIAN.
- WELL DEPTHS AND MUD VOLUMES FOR LOCATIONS W6 MERIDIAN.

Well Depths and Mud Volumes (all locations).

Sump Key	Sump Number	Legal Location	ERCB Region	Waste Type	Meridian	Well Depth, m	Mud Vol, m3	Solid Vol, m3	Liq Vol, m3
3	SC3	11-35-57-19-W5	6	KCl	5	3358			
4	SC4	7-23-54-20-W5	6	KCl	5	3933			
5	SC5	7-23-54-20-W5	6	Gel	5				
6	SC6	8-1-53-24-W5	6	Invert	5	4670			
7	SC7	11-21-50-20-W5	6	Gel	5	4510			
8	SC8	8-1-52-18-W5	6	Gel	5				
9	SC9A	14-23-23-4-W5	4	Gel	5	450	475.0	430.0	45.0
9	SC9B	14-23-23-4-W	4	Invert	5	3000	528.0	336.0	192.0
10	SC10	16-3-15-26-W4	4	Gel	4	2085	648.0	612.0	36.0
11	SC11	16-10-6-1-W4	8	Gel	4	1155	178.0	157.0	21.0
12	SC12	14-4-24-16-W4	4	KCl	4	617	77.5	53.5	24.0
13	SC13	12-32-12-13-W4	8	Gel	4	985	258.0	110.0	148.0
14	SC14A	8-32-32-4-W5	8	Gel	5	2436	546.0	146.0	400.0
15	SC15	9-5-20-21-W4	4	Gel	4	1470	461.0	183.0	278.0
16	SC16	15-21-26-7-W4	8	Gel	4	968	210.0	135.0	75.0
17	SC17	5-1-21-2-W4	8	Gel	4	948	257.0	120.0	137.0
18	SC18	11-10-7-22-W4	8	Gel	4	1090	313.0	205.0	108.0
19	SC19B	3-21-4-30-W5	4	KCl	5	3570	3633.0	1282.0	2351.0
21	SC21	NE-10-56-20-W4	7	Gel	4		590.0	590.0	0.0
22	SC22	NW-18-59-2-W4	5	Gel	4	597			
23	SC23	3-8-59-2-W4	5	Gel	4	612			
24	SC24	8-27-58-17-W5	7	Gel	5	3100	1794.0	1148.2	645.8
25	SC25	10-17-74-23-W5	10	Gel	5		1683.0	373.0	1310.0
26	SC26	4-24-73-17-W5	7	Gel	5	2330	784.0	672.0	112.0
27	SC27	2-26-72-4-W5	7	Gel	5	1675	920.0	288.0	632.0
28	SC28	6-23-80-11-W5	7	Gel	5	1770	839.0	571.0	268.0
29	SC29	6-15-93-06-W5	7	KCl	5	1316	1747.0	600.0	1147.0
30	SC30A	9-15-90-10-W5	7	KCl	5		893.0	17.0	876.0
31	SC31	11-16-89-7-W5	7	ND	5	1447	359.0	2.0	357.0
32	SC32	9-5-79-11-W5	7	Gel	5	1910	1765.0	561.0	1204.0
33	SC33	6-11-76-23-W4	7	Gel	4	679	249.0	225.0	24.0
34	SC34	4-33-47-9-W5	6	Gel	5	2300	4523.0	1750.0	2773.0
35	SC35	6-3-48-13-W5	6	Gel	5	3323	5529.0	3643.0	1886.0
36	SC36	6-33-56-10-W5	6	KCl	5	1723	728.0	501.0	227.0
37	SC37	4-34-47-6-W5	6	POLYMER	5	1520	1058.0	383.0	675.0
38	SC38	14-10-48-7-W5	6	POLYMER	5	1500	926.0	278.0	648.0
39	SC39	2-28-38-4-W5	9	Gel	5	2317	1122.0	639.0	483.0
40	SC40	8-29-38-4-W5	9	Gel	5	3230	5785.0	1639.0	4146.0
41	SC41	2-4-115-5-W6	7	KCl	6	1523	1498.0	681.0	817.0
42	SC42	14-16-110-6-W6	7	Gel	6	1645	502.0	133.0	369.0
43	SC43	7-18-81-25-W5	10	Gel	5	1953	895.0	382.0	513.0
44	SC44	4-13-88-12-W5	7	Gel	5	1640	660.0	146.0	514.0
45	SC45	4-12-77-3-W6	10	Gel	6	2584	2330.0	768.0	1562.0
46	SC46	7-29-71-7-W6	10	Gel	6	2286	1290.0	781.0	509.0
47	SC47	11-6-73-10-W6	10	Gel	6	1495	921.0	553.0	368.0
48	SC48	1-17-68-8-W6	10	Gel	6	1725	1634.0	551.0	1083.0
49	SC49	2-34-80-5-W6	10	Gel	6	2318	1576.0	1107.0	469.0
50	SC50	6-26-80-12-W6	10	Gel	6	2552	1710.0	828.0	882.0

(Continued). Well Depths and Mud Volumes (all locations).

Sump Key	Sump Number	Legal Location	ERCB Region	Waste Type	Meridian	Well Depth, m	Mud Vol, m3	Solid Vol, m3	Liq Vol, m3
51	SC51	1-27-41-03-W5	9	Gel	5	2195			
52	SC52A	6-4-37-16-W4	9	NaCl	4	2067			
53	SC53	16-27-33-13-W4	3	KCl	4		730.0	230.0	500.0
54	SC54	14-2-31-20-W4	9	Gel	4	1386	816.0	477.0	339.0
55	SC55	6-11-33-28-W4	9	Gel	4	1869	880.0	577.0	303.0
56	SC56A	15-12-21-4-W5	4	KCl	5	3340	653.0	405.0	248.0
57	SC57	10-9-21-4-W5	4	Invert	5	4072	425.0	423.0	2.0
58	SC58	1-22-20-26-W4	4	KCl	4	1986	611.0	401.0	210.0
59	SC59	3-20-32-2-W5	9	KCl	5	2465	1305.0	346.0	959.0
60	SC60	7-10-34-5-W5	9	K2C03	5	2774	1014.0	320.0	694.0
61	SC61	10-16-34-7-W5	9	Invert	5	4300	1730.0	755.0	975.0
62	SC62A	9-16-34-8-W5	9	Gel	5	457	301.0	279.0	22.0
62	SC62D	9-16-34-8-W5	9	Invert	5	4043	939.0	256.0	683.0
63	SC63	6-9-7-16-W4	8	Gel	4	1020	465.0	117.0	348.0
64	SC64	11-5-3-12-W4	8	Gel	4		374.0	114.0	260.0
65	SC65	10-35-16-3-W4	8	SAPP	4	602	55.0	42.0	13.0
66	SC66	13-22-14-4-W4	8	SAPP	4	511	40.0	22.0	18.0
67	SC67	6-14-20-9-W4	8	Gel	4	1045	220.0	52.0	168.0
68	SC68	6-3-24-13-W4	8	Invert	4	715	77.0	77.0	0.0
69	SC69	15-32-37-7-W5	9	Invert	5	3760	665.0	402.0	263.0
70	SC70	6-13-37-8-W5	9	Invert	5	2745	292.0	136.0	156.0
71	SC71A	8-23-36-9-W5	9	Invert	5	297	143.0	143.0	0.0
71	SC71C	8-23-36-9-W5	9	Gel	5	2543	135.0	95.0	40.0
72	SC72A	10-25-33-8-W5	9	Gel	5	407	113.0	73.0	40.0
72	SC72C	10-25-33-8-W	9	Invert	5	2793	444.0	160.0	284.0
73	SC73	15-14-36-5-W5	9	Gel	5	2613	619.0	422.0	197.0
74	SC74	14-28-38-24-W4	9	KCl	4		632.0	229.0	403.0
75	SC75	11-5-42-22-W4	9	Gel	4	1795	143.0	66.0	77.0
76	SC76	9-24-36-19-W4	9	Gel	4	1277	480.0	240.0	240.0
77	SC77	6-21-44-4-W5	9	Gel	5	1900	1436.0	582.0	854.0
78	SC78	5-27-22-24-W4	4	KCl	4	1669	207.0	207.0	0.0
79	SC79	8-20-27-3-W5	4	Invert	5	4975	340.0	340.0	0.0
80	SC80	16-4-65-4-W6	10	Gel	6	3960	3396.0	1622.0	1774.0
81	SC81	16-36-65-4-W6	10	Invert	6	3860	2595.0	1117.0	1478.0
82	SC82	16-36-65-4-W6	6	Gel	6	2690	3276.0	896.0	2380.0
83	SC83	2-1-47-2-W5	6	Gel	5	1055	1034.0	287.0	747.0
84	SC84	10-16-54-27-W4	7	Gel	4	1338	840.0	261.0	579.0
85	SC85	13-2-64-21-W4	7	Gel	4	794	529.0	78.0	451.0
86	SC86	12-30-59-25-W4	7	Gel	4	1034	481.0	112.0	369.0
87	SC87	6-36-61-14-W4	5	Gel	4	641	346.0	168.0	178.0
88	SC88	6-29-55-6-W4	5	Gel	4	709	394.0	275.0	119.0
89	SC89	1-15-49-10-W4	3	Gel	4	810	222.0	60.0	162.0
90	SC90	15-29-40-1-W4	3	Gel	4	835	235.0	41.0	194.0
91	SC91	1A-30-38-3-W4	3	Gel	4	854	487.0	487.0	0.0
92	SC92	7-33-36-5-W4	3	Gel	4	970	419.0	96.0	323.0
93	SC93	16-27-42-2-W4	3	Gel	4	542	773.0	501.0	272.0
94	SC94	10-19-43-19-W4	9	Gel	4	1337	727.0	226.0	501.0
95	SC95	16-34-58-24-W5	6	Gel	5	3968	3065.0	2259.0	806.0

(Concluded). Well Depths and Mud Volumes (all locations).

Sump Key	Sump Number	Legal Location	ERCB Region	Waste Type	Meridian	Well Depth, m	Mud Vol, m3	Solid Vol, m3	Liq Vol, m3
96	SC96	2-21-67-18-W5	10	Gel	5	2835	222.0	0.0	222.0
97	SC97	6-33-35-5-W5	9	K-ACETATE	5	2750	877.0	349.0	528.0
98	SC98	16-26-40-7-W5	9	KCl	5	2601	1328.0	735.0	593.0
99	SC99	8-24-37-8-W5	9	Invert	5	2750	549.0	340.0	209.0
100	SC100	6-5-46-23-W4	7	Gel	4	1430	689.0	134.0	555.0
101	SC101	14-4-32-21-W4	9	METAL-OH	4	1465	465.0	188.0	277.0
102	SC102	8-16-36-20-W4	9	KCl	4	722	147.0	87.0	60.0
103	SC103	16-21-32-3-W4	8	KCl	4	860	294.0	189.0	105.0
104	SC104	16-24-36-7-W4	3	SAPP	4		509.0	314.0	195.0
105	SC105	16-31-55-2-W5	7	KCl	5	1150	575.0	308.0	267.0
106	SC106	8-9-56-3-W5	7	KCl	5	1385	583.0	285.0	298.0
107	SC107	12-7-55-19-W5	6	KCl	5	3850	1250.0	780.0	470.0
108	SC108	7-9-55-21-W5	6	Invert	5	3860	2702.0	1554.0	1148.0
200	SC200	20-36-13-W5	9	Gel	5	5443	216.0	216.0	0.0
201	SC201	10-13-35-26-W4	9	Gel	4	1560	741.0	287.0	454.0
202	SC202	11-11-38-15-W5	9	Gel	5	5443	12210.0	10395.0	1815.0
203	SC203	15-14-9-5-W5	4	Gel	5	3896	1646.0	1234.0	412.0
204	SC204	11-9-4-W5	4	Gel	5		1822.0	0.0	1822.0
205	SC205	11-25-16-5-W4	8	KCl	4	425	92.0	16.0	76.0
206	SC206	8-34-55-20-W4	7	NaCl	4	1870	416.0	214.0	202.0

Well Depths and Mud Volumes for Locations W4 Meridian.

Sump Key	Sump Number	Legal Location	ERCB Region	Waste Type	Meridian	Well Depth, m	Mud Vol, m3	Solid Vol, m3	Liq Vol, m3
10	SC10	16-3-15-26-W4	4	Gel	4	2085	648.0	612.0	36.0
11	SC11	16-10-6-1-W4	8	Gel	4	1155	178.0	157.0	21.0
12	SC12	14-4-24-16-W4	4	KCl	4	617	77.5	53.5	24.0
13	SC13	12-32-12-13-W4	8	Gel	4	985	258.0	110.0	148.0
15	SC15	9-5-20-21-W4	4	Gel	4	1470	461.0	183.0	278.0
16	SC16	15-21-26-7-W4	8	Gel	4	968	210.0	135.0	75.0
17	SC17	5-1-21-2-W4	8	Gel	4	948	257.0	120.0	137.0
18	SC18	11-10-7-22-W4	8	Gel	4	1090	313.0	205.0	108.0
21	SC21	NE-10-56-20-W4	7	Gel	4		590.0	590.0	0.0
22	SC22	NW-18-59-2-W4	5	Gel	4	597			
23	SC23	3-8-59-2-W4	5	Gel	4	612			
33	SC33	6-11-76-23-W4	7	Gel	4	679	249.0	225.0	24.0
52	SC52A	6-4-37-16-W4	9	NaCl	4	2067			
53	SC53	16-27-33-13-W4	3	KCl	4		730.0	230.0	500.0
54	SC54	14-2-31-20-W4	9	Gel	4	1386	816.0	477.0	339.0
55	SC55	6-11-33-28-W4	9	Gel	4	1869	880.0	577.0	303.0
58	SC58	1-22-20-26-W4	4	KCl	4	1986	611.0	401.0	210.0
63	SC63	6-9-7-16-W4	8	Gel	4	1020	465.0	117.0	348.0
64	SC64	11-5-3-12-W4	8	Gel	4		374.0	114.0	260.0
65	SC65	10-35-16-3-W4	8	SAPP	4	602	55.0	42.0	13.0
66	SC66	13-22-14-4-W4	8	SAPP	4	511	40.0	22.0	18.0
67	SC67	6-14-20-9-W4	8	Gel	4	1045	220.0	52.0	168.0
68	SC68	6-3-24-13-W4	8	Invert	4	715	77.0	77.0	0.0
74	SC74	14-28-38-24-W4	9	KCl	4		632.0	229.0	403.0
75	SC75	11-5-42-22-W4	9	Gel	4	1795	143.0	66.0	77.0
76	SC76	9-24-36-19-W4	9	Gel	4	1277	480.0	240.0	240.0
78	SC78	5-27-22-24-W4	4	KCl	4	1669	207.0	207.0	0.0
84	SC84	10-16-54-27-W4	7	Gel	4	1338	840.0	261.0	579.0
85	SC85	13-2-64-21-W4	7	Gel	4	794	529.0	78.0	451.0
86	SC86	12-30-59-25-W4	7	Gel	4	1034	481.0	112.0	369.0
87	SC87	6-36-61-14-W4	5	Gel	4	641	346.0	168.0	178.0
88	SC88	6-29-55-6-W4	5	Gel	4	709	394.0	275.0	119.0
89	SC89	1-15-49-10-W4	3	Gel	4	810	222.0	60.0	162.0
90	SC90	15-29-40-1-W4	3	Gel	4	835	235.0	41.0	194.0
91	SC91	1A-30-38-3-W4	3	Gel	4	854	487.0	487.0	0.0
92	SC92	7-33-36-5-W4	3	Gel	4	970	419.0	96.0	323.0
93	SC93	16-27-42-2-W4	3	Gel	4	542	773.0	501.0	272.0
94	SC94	10-19-43-19-W4	9	Gel	4	1337	727.0	226.0	501.0
100	SC100	6-5-46-23-W4	7	Gel	4	1430	689.0	134.0	555.0
101	SC101	14-4-32-21-W4	9	METAL-OH	4	1465	465.0	188.0	277.0
102	SC102	8-16-36-20-W4	9	KCl	4	722	147.0	87.0	60.0
103	SC103	16-21-32-3-W4	8	KCl	4	860	294.0	189.0	105.0
104	SC104	16-24-36-7-W4	3	SAPP	4		509.0	314.0	195.0
201	SC201	10-13-35-26-W4	9	Gel	4	1560	741.0	287.0	454.0
205	SC205	11-25-16-5-W4	8	KCl	4	425	92.0	16.0	76.0
206	SC206	8-34-55-20-W4	7	NaCl	4	1870	416.0	214.0	202.0

Well Depths and Mud Volumes for Locations W5 Meridian

Sump Key	Sump Number	Legal Location	ERCB Region	Waste Type	Meridian	Well Depth, m	Mud Vol, m3	Solid Vol, m3	Liq Vol, m3
3	SC3	11-35-57-19-W5	6	KCl	5	3358			
4	SC4	7-23-54-20-W5	6	KCl	5	3933			
5	SC5	7-23-54-20-W5	6	Gel	5				
6	SC6	8-1-53-24-W5	6	Invert	5	4670			
7	SC7	11-21-50-20-W5	6	Gel	5	4510			
8	SC8	8-1-52-18-W5	6	Gel	5				
9	SC9A	14-23-23-4-W5	4	Gel	5	450	475.0	430.0	45.0
9	SC9B	14-23-23-4-W	4	Invert	5	3000	528.0	336.0	192.0
14	SC14A	8-32-32-4-W5	8	Gel	5	2436	546.0	146.0	400.0
19	SC19B	3-21-4-30-W5	4	KCl	5	3570	3633.0	1282.0	2351.0
24	SC24	8-27-58-17-W5	7	Gel	5	3100	1794.0	1148.2	645.8
25	SC25	10-17-74-23-W5	10	Gel	5		1683.0	373.0	1310.0
26	SC26	4-24-73-17-W5	7	Gel	5	2330	784.0	672.0	112.0
27	SC27	2-26-72-4-W5	7	Gel	5	1675	920.0	288.0	632.0
28	SC28	6-23-80-11-W5	7	Gel	5	1770	839.0	571.0	268.0
29	SC29	6-15-93-06-W5	7	KCl	5	1316	1747.0	600.0	1147.0
30	SC30A	9-15-90-10-W5	7	KCl	5		893.0	17.0	876.0
31	SC31	11-16-89-7-W5	7	ND	5	1447	359.0	2.0	357.0
32	SC32	9-5-79-11-W5	7	Gel	5	1910	1765.0	561.0	1204.0
34	SC34	4-33-47-9-W5	6	Gel	5	2300	4523.0	1750.0	2773.0
35	SC35	6-3-48-13-W5	6	Gel	5	3323	5529.0	3643.0	1886.0
36	SC36	6-33-56-10-W5	6	KCl	5	1723	728.0	501.0	227.0
37	SC37	4-34-47-6-W5	6	POLYMER	5	1520	1058.0	383.0	675.0
38	SC38	14-10-48-7-W5	6	POLYMER	5	1500	926.0	278.0	648.0
39	SC39	2-28-38-4-W5	9	Gel	5	2317	1122.0	639.0	483.0
40	SC40	8-29-38-4-W5	9	Gel	5	3230	5785.0	1639.0	4146.0
43	SC43	7-18-81-25-W5	10	Gel	5	1953	895.0	382.0	513.0
44	SC44	4-13-88-12-W5	7	Gel	5	1640	660.0	146.0	514.0
51	SC51	1-27-41-03-W5	9	Gel	5	2195			
56	SC56A	15-12-21-4-W5	4	KCl	5	3340	653.0	405.0	248.0
57	SC57	10-9-21-4-W5	4	Invert	5	4072	425.0	423.0	2.0
59	SC59	3-20-32-2-W5	9	KCl	5	2465	1305.0	346.0	959.0
60	SC60	7-10-34-5-W5	9	K2C03	5	2774	1014.0	320.0	694.0
61	SC61	10-16-34-7-W5	9	Invert	5	4300	1730.0	755.0	975.0
62	SC62A	9-16-34-8-W5	9	Gel	5	457	301.0	279.0	22.0
62	SC62D	9-16-34-8-W5	9	Invert	5	4043	939.0	256.0	683.0
69	SC69	15-32-37-7-W5	9	Invert	5	3760	665.0	402.0	263.0
70	SC70	6-13-37-8-W5	9	Invert	5	2745	292.0	136.0	156.0
71	SC71A	8-23-36-9-W5	9	Invert	5	297	143.0	143.0	0.0
71	SC71C	8-23-36-9-W5	9	Gel	5	2543	135.0	95.0	40.0
72	SC72A	10-25-33-8-W5	9	Gel	5	407	113.0	73.0	40.0
72	SC72C	10-25-33-8-W	9	Invert	5	2793	444.0	160.0	284.0
73	SC73	15-14-36-5-W5	9	Gel	5	2613	619.0	422.0	197.0
77	SC77	6-21-44-4-W5	9	Gel	5	1900	1436.0	582.0	854.0
79	SC79	8-20-27-3-W5	4	Invert	5	4975	340.0	340.0	0.0
83	SC83	2-1-47-2-W5	6	Gel	5	1055	1034.0	287.0	747.0
95	SC95	16-34-58-24-W5	6	Gel	5	3968	3065.0	2259.0	806.0
96	SC96	2-21-67-18-W5	10	Gel	5	2835	222.0	0.0	222.0

(Concluded). Well Depths and Mud Volumes for Locations W5 Meridian.

Sump Key	Sump Number	Legal Location	ERCB Region	Waste Type	Meridian	Well Depth, m	Mud Vol, m3	Solid Vol, m3	Liq Vol, m3
97	SC97	6-33-35-5-W5	9	K-ACETATE	5	2750	877.0	349.0	528.0
98	SC98	16-26-40-7-W5	9	KCl	5	2601	1328.0	735.0	593.0
99	SC99	8-24-37-8-W5	9	Invert	5	2750	549.0	340.0	209.0
105	SC105	16-31-55-2-W5	7	KCl	5	1150	575.0	308.0	267.0
106	SC106	8-9-56-3-W5	7	KCl	5	1385	583.0	285.0	298.0
107	SC107	12-7-55-19-W5	6	KCl	5	3850	1250.0	780.0	470.0
108	SC108	7-9-55-21-W5	6	Invert	5	3860	2702.0	1554.0	1148.0
200	SC200	20-36-13-W5	9	Gel	5	5443	216.0	216.0	0.0
202	SC202	11-11-38-15-W5	9	Gel	5	5443	12210.0	10395.0	1815.0
203	SC203	15-14-9-5-W5	4	Gel	5	3896	1646.0	1234.0	412.0
204	SC204	11-9-4-W5	4	Gel	5		1822.0	0.0	1822.0

Well Depths and Mud Volumes for Locations W6 Meridian.

Sump Key	Sump Number	Legal Location	ERCB Region	Waste Type	Meridian	Well Depth, m	Mud Vol, m3	Solid Vol, m3	Liq Vol, m3
41	SC41	2-4-115-5-W6	7	KCl	6	1523	1498	681	817
42	SC42	14-16-110-6-W6	7	Gel	6	1645	502	133	369
45	SC45	4-12-77-3-W6	10	Gel	6	2584	2330	768	1562
46	SC46	7-29-71-7-W6	10	Gel	6	2286	1290	781	509
47	SC47	11-6-73-10-W6	10	Gel	6	1495	921	553	368
48	SC48	1-17-68-8-W6	10	Gel	6	1725	1634	551	1083
49	SC49	2-34-80-5-W6	10	Gel	6	2318	1576	1107	469
50	SC50	6-26-80-12-W6	10	Gel	6	2552	1710	828	882
80	SC80	16-4-65-4-W6	10	Gel	6	3960	3396	1622	1774
81	SC81	16-36-65-4-W6	10	Invert	6	3860	2595	1117	1478
82	SC82	16-36-65-4-W6	6	Gel	6	2690	3276	896	2380

APPENDIX 3: STATISTICAL PARAMETERS FOR THE LIQUID PHASE SAMPLES

Statistical Parameters of the Freshwater Gel Liquid Phase Samples.

Parameter	pH Lab	pH Field	E.C.	Cl	NH4	Alk.	HCO3	CO3	OH	NO3-N	Al
							(mg/L)				
Count (N)	157.00	150.00	157.00	157.00	157.00	157.00	157.00	157.00	157.00	157.00	157.00
Sum	1417.31	1387.27	534.00	85376.16	215.01	60952.90	42941.32	12899.14	5104.75	2044.06	393.25
Mean	9.03	9.25	3.40	543.80	1.37	388.24	273.51	82.16	32.51	13.02	2.50
SEM	0.09	0.10	0.22	116.04	0.20	19.83	15.32	11.95	11.81	3.99	0.82
Median	8.74	9.21	2.67	157.00	0.35	363.00	245.00	20.40	0.29	0.07	1.00
Variance	1.21	1.41	7.26	2114051.88	6.32	61717.80	36844.86	22409.20	21893.61	2502.08	105.74
StDev (sd)	1.10	1.19	2.69	1453.98	2.51	248.43	191.95	149.70	147.96	50.02	10.28
Maximum	12.40	12.50	13.40	9760.00	16.70	1550.00	1230.00	1210.00	1060.00	300.00	128.00
Minimum	7.24	6.10	0.14	5.21	0.00	38.30	0.00	0.00	0.01	0.00	0.10
Range	5.16	6.40	13.26	9754.79	16.70	1511.70	1230.00	1210.00	1059.99	300.00	127.90
Skewness	1.07	0.04	1.66	4.67	3.22	1.59	1.35	3.72	5.66	4.55	11.81
Kurtosis	0.99	0.05	2.88	21.86	12.79	4.13	3.64	20.92	33.22	20.94	144.72

E.C. = Electrical Conductivity (dS/m); Alk = Alkalinity (mg CaCO3/L); HCO3, CO3, OH reported as mg CaCO3/L;

Parameter	Cr	Fe	V	Ti	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na
							(mg/L)					
Count (N)	157.00	157.00	157.00	157.00	157.00	157.00	157.00	157.00	157.00	157.00	157.00	157.00
Sum	32.47	257.41	8.94	13.18	0.84	2.22	9.56	24.73	15.63	8483.04	2432.11	130155.08
Mean	0.21	1.64	0.06	0.08	0.01	0.01	0.06	0.16	0.10	54.03	15.49	829.01
SEM	0.04	0.29	0.01	0.04	0.00	0.00	0.00	0.02	0.02	5.24	3.84	51.23
Median	0.01	0.79	0.02	0.02	0.01	0.01	0.05	0.11	0.03	22.70	3.43	664.00
Variance	0.20	13.46	0.01	0.21	0.00	0.00	0.00	0.05	0.04	4305.38	2311.22	412036.62
StDev (sd)	0.45	3.67	0.08	0.46	0.00	0.02	0.04	0.22	0.20	65.62	48.08	641.90
Maximum	3.59	40.60	0.65	5.48	0.02	0.15	0.29	1.63	1.54	319.00	375.00	3470.00
Minimum	0.01	0.01	0.02	0.01	0.01	0.01	0.05	0.01	0.00	3.51	0.05	6.58
Range	3.58	40.60	0.64	5.48	0.02	0.14	0.24	1.62	1.54	315.49	374.95	3463.42
Skewness	4.08	8.16	3.67	10.78	5.59	3.44	4.08	4.23	4.75	1.93	5.87	1.59
Kurtosis	23.01	82.67	19.80	123.34	33.05	14.13	17.84	21.25	26.90	3.34	37.54	2.74

Parameter	K	Li	Sr	B	Ba	P	Mo	Ni	Se	Co	SO4	Si	As
							(mg/L)						
Count (N)	157.00	157.00	157.00	157.00	157.00	157.00	157.00	157.00	157.00	157.00	157.00	157.00	157.00
Sum	6417.90	10.20	114.64	91.27	19.45	531.03	17.66	3.60	27.66	1.11	166584.41	2364.80	11.80
Mean	40.88	0.06	0.73	0.58	0.12	3.38	0.11	0.02	0.18	0.01	1061.05	15.06	0.08
SEM	25.09	0.01	0.09	0.04	0.01	0.67	0.01	0.00	0.01	0.00	93.36	2.34	0.01
Median	11.50	0.02	0.43	0.39	0.08	0.29	0.09	0.02	0.15	0.01	612.00	8.17	0.04
Variance	98829.94	0.02	1.22	0.29	0.02	71.40	0.01	0.00	0.01	0.00	1368572.29	861.02	0.01
StDev (sd)	314.37	0.13	1.11	0.53	0.13	8.45	0.09	0.02	0.10	0.01	1169.86	29.34	0.11
Maximum	3950.00	0.99	10.80	3.39	0.65	52.60	0.51	0.12	0.90	0.04	6210.00	333.00	1.06
Minimum	1.59	0.02	0.03	0.02	0.00	0.05	0.03	0.02	0.15	0.00	6.51	0.93	0.02
Range	3948.41	0.97	10.78	3.37	0.65	52.55	0.49	0.10	0.75	0.04	6203.49	332.07	1.05
Skewness	12.48	5.51	5.63	1.78	1.89	3.76	1.43	2.64	4.97	3.31	2.05	8.58	5.33
Kurtosis	156.21	33.31	44.79	4.71	3.34	14.97	3.02	6.70	27.72	11.54	4.67	89.69	42.59

(Concluded). Statistical Parameters of the Freshwater Gel Liquid Phase Samples.

Parameter	T. Residue g/L	EC50 5min(%)	EC50 15min(%)	Oil mg/L	Benzene (mg/Kg)	Toluene (mg/Kg)	Ethyl Benzene (mg/Kg)	P-Xylene (mg/Kg)	M-Xylene (mg/Kg)	O-Xylene (mg/Kg)
Count (N)	157.00	72.00	71.00	62.00	67.00	67.00	67.00	67.00	67.00	67.00
Sum	11937.87	3536.03	3264.78	33183.72	15.18	4.36	3.41	1.91	2.61	2.61
Mean	76.04	49.11	45.98	535.22	0.23	0.07	0.05	0.03	0.04	0.04
SEM	6.81	4.31	4.41	385.62	0.14	0.04	0.01	0.00	0.01	0.01
Median	52.60	41.65	34.00	2.88	0.03	0.03	0.03	0.03	0.03	0.03
Variance	7279.43	1340.25	1377.83	9219762.30	1.30	0.11	0.01	0.00	0.01	0.01
StDev (sd)	85.32	36.61	37.12	3036.41	1.14	0.33	0.12	0.03	0.11	0.08
Maximum	534.00	100.00	100.00	23300.00	8.72	2.71	0.87	0.26	0.96	0.61
Minimum	0.24	1.12	0.41	0.33	0.03	0.03	0.03	0.03	0.03	0.03
Range	533.77	98.88	99.59	23299.67	8.70	2.69	0.85	0.23	0.94	0.59
Skewness	1.88	0.31	0.42	7.22	6.77	8.19	5.76	8.19	8.19	6.15
Kurtosis	5.37	-1.46	-1.44	54.16	48.91	67.00	36.83	67.00	67.00	38.68

T.Residue = Total Residue (g/L); Microtox Analysis = EC50 (5 or 15 minutes); Trout (LC50(%)) = Concentration of solution lethal to 50% of the trout in 96 hours of exposure; Trout Survival = Number of 3 possible fish that survive for 96 hours.

Parameter	Trout LC50(%)	Trout Survival
Count (N)	67.00	62.00
Sum	1877.65	24.00
Mean	28.02	0.39
SEM	3.92	0.12
Median	16.00	0.00
Variance	1029.61	0.83
StDev (sd)	32.09	0.91
Maximum	100.00	3.00
Minimum	0.05	0.00
Range	99.95	3.00
Skewness	1.37	2.22
Kurtosis	0.53	3.52

Statistical Parameters of the Invert Liquid Phase Samples.

Parameter	pH		E.C.	Cl	NH4	Alk.	HCO3	CO3	OH	NO3-N	Al	Cr
	Lab	Field					(mg/L)					
Count (N)	35.00	33.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
Sum	295.74	271.04	123.59	27204.10	30.89	10644.50	6133.13	3324.81	1186.18	16.81	51.57	0.55
Mean	8.45	8.21	3.53	777.26	0.88	304.13	175.23	94.99	33.89	0.48	1.47	0.02
SEM	0.28	0.31	0.63	140.22	0.39	49.73	28.64	35.43	16.58	0.29	0.19	0.00
Median	7.72	7.63	2.06	590.00	0.00	177.00	129.00	1.72	0.03	0.02	1.20	0.01
Variance	2.77	3.18	14.03	688188.09	5.27	86573.71	28718.75	43944.40	9619.41	2.89	1.27	0.00
StDev (sd)	1.67	1.78	3.75	829.57	2.30	294.23	169.47	209.63	98.08	1.70	1.13	0.01
Maximum	11.90	11.80	15.30	3550.00	10.30	1270.00	713.00	880.00	397.00	9.90	5.78	0.03
Minimum	5.70	5.25	0.30	37.30	0.00	15.60	1.09	0.01	0.00	0.00	0.10	0.01
Range	6.20	6.55	15.00	3512.70	10.30	1254.40	711.91	879.99	397.00	9.90	5.68	0.02
Skewness	0.81	0.44	1.52	1.73	3.03	1.65	1.52	2.81	3.18	5.33	1.77	0.42
Kurtosis	-0.38	-0.70	1.87	3.17	9.14	2.73	2.21	7.85	9.31	29.90	5.11	-1.76

E.C. = Electrical Conductivity (dS/m); Alk = Alkalinity (mg CaCO3/L); HCO3, CO3, OH reported as mg CaCO3/L; T.Residue = Total Residue (g/L).

Parameter	Fe	V	Ti	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na	K
							(mg/L)					
Count (N)	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
Sum	7.15	1.18	2.24	0.30	1.80	4.34	4.75	5.29	8260.96	379.93	12075.36	705.37
Mean	0.20	0.03	0.06	0.01	0.05	0.12	0.14	0.15	236.03	10.86	345.01	20.15
SEM	0.12	0.00	0.01	0.00	0.01	0.01	0.03	0.03	52.77	4.31	66.36	3.92
Median	0.04	0.03	0.07	0.01	0.05	0.13	0.09	0.10	103.00	4.65	171.00	10.30
Variance	0.46	0.00	0.00	0.00	0.00	0.00	0.03	0.04	97480.08	650.89	154135.29	536.58
StDev (sd)	0.68	0.02	0.03	0.00	0.03	0.06	0.17	0.20	312.22	25.51	392.60	23.16
Maximum	4.05	0.12	0.13	0.02	0.14	0.25	0.92	0.91	1480.00	149.00	1370.00	119.00
Minimum	0.01	0.02	0.01	0.01	0.01	0.05	0.01	0.00	7.96	0.05	6.20	3.39
Range	4.05	0.10	0.12	0.01	0.14	0.20	0.91	0.90	1472.04	148.95	1363.80	115.61
Skewness	5.62	2.03	-0.38	0.12	0.83	-0.02	3.30	2.16	2.35	5.00	1.36	2.81
Kurtosis	32.48	7.09	-0.59	-1.84	0.72	-0.85	13.85	5.86	6.73	27.01	0.94	9.56

Parameter	Li	Sr	B	Ba	P	Mo	Ni	Se	Co	S04	Si	As	T.Residue g/L
							(mg/L)						
Count (N)	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
Sum	2.03	89.54	7.03	11.11	16.42	1.88	1.84	6.27	0.71	13435.73	239.91	2.05	1558.02
Mean	0.06	2.56	0.20	0.32	0.47	0.05	0.05	0.18	0.02	383.88	6.85	0.06	44.51
SEM	0.01	0.70	0.04	0.12	0.17	0.01	0.00	0.01	0.00	99.72	1.17	0.01	13.12
Median	0.06	1.01	0.12	0.13	0.12	0.03	0.05	0.15	0.02	99.90	3.48	0.05	5.29
Variance	0.00	16.95	0.06	0.50	1.01	0.00	0.00	0.00	0.00	348037.32	48.22	0.00	6027.67
StDev (sd)	0.03	4.12	0.24	0.71	1.01	0.05	0.03	0.07	0.01	589.95	6.94	0.05	77.64
Maximum	0.15	22.20	1.12	4.24	5.11	0.24	0.11	0.34	0.04	2170.00	30.50	0.24	403.00
Minimum	0.02	0.11	0.02	0.04	0.05	0.03	0.02	0.15	0.01	9.00	1.59	0.02	0.12
Range	0.13	22.09	1.10	4.20	5.06	0.21	0.10	0.19	0.03	2161.00	28.91	0.22	402.88
Skewness	1.22	3.49	2.71	5.32	3.75	2.11	0.26	1.85	-0.63	1.96	2.07	1.94	3.25
Kurtosis	2.77	15.24	7.90	29.98	14.87	4.42	0.01	1.56	-1.06	2.93	3.59	4.54	13.22

(Concluded). Statistical Parameters of the Invert Liquid Phase Samples.

Parameter	----- EC50 -----		Oil	Benzene	Toluene	Ethyl Benzene	P-Xylene	M-Xylene	O-Xylene	Trout
	5min(%)	15min(%)	mg/L	-------------------------		(mg/Kg)		-------------------------		LC50(%)
Count (N)	19.00	19.00	17.00	19.00	19.00	19.00	19.00	19.00	19.00	17.00
Sum	197.87	209.64	182614.55	32.54	0.48	0.48	0.48	0.65	0.52	317.80
Mean	10.41	11.03	10742.03	1.71	0.03	0.03	0.03	0.03	0.03	18.69
SEM	5.21	5.25	6286.75	0.60	0.00	0.00	0.00	0.01	0.00	7.68
Median	3.42	3.16	661.00	0.57	0.03	0.03	0.03	0.03	0.03	4.00
Variance	516.58	523.69	671895805.00	6.92	0.00	0.00	0.00	0.00	0.00	1003.38
StDev (sd)	22.73	22.88	25920.95	2.63	0.00	0.00	0.00	0.03	0.01	31.68
Maximum	100.00	100.00	106000.00	8.19	0.03	0.03	0.03	0.16	0.07	100.00
Minimum	0.15	0.13	1.11	0.03	0.03	0.03	0.03	0.03	0.03	0.50
Range	99.85	99.87	105998.89	8.17	0.00	0.00	0.00	0.14	0.05	99.50
Skewness	3.79	3.64	3.50	1.79				3.77	4.36	2.12
Kurtosis	15.20	14.22	13.01	2.26				14.71	19.00	3.35

Microtox Analysis = EC50 (5 or 15 minutes); Trout (LC50(%)) = Concentration of solution lethal to 50% of the trout in 96 hours of exposure; Trout Survival = Number of 3 possible fish that survive for 96 hours.

Parameter	Trout Survival
Count (N)	17.00
Sum	3.00
Mean	0.18
SEM	0.13
Median	0.00
Variance	0.28
StDev (sd)	0.53
Maximum	2.00
Minimum	0.00
Range	2.00
Skewness	3.14
Kurtosis	9.80

Statistical Parameters of the KCl Liquid Phase Samples.

Parameter	pH Lab	pH Field	E.C.	Cl	NH4	Alk.	HCO3	CO3	OH	NO3-N	Al
			(mg/L)								
Count (N)	60.00	54.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Sum	536.41	477.44	979.55	326496.80	205.26	26439.50	19080.42	3384.53	3982.09	48.90	80.87
Mean	8.94	8.84	16.33	5441.61	3.42	440.66	318.01	56.41	66.37	0.82	1.35
SEM	0.17	0.20	1.88	728.96	0.87	55.81	46.01	22.35	28.12	0.54	0.19
Median	8.41	8.55	12.60	3370.00	0.35	242.50	176.50	7.89	0.13	0.06	0.89
Variance	1.81	2.27	212.50	31883061.66	45.87	186876.88	127011.86	29967.63	47449.97	17.60	2.16
StDev (sd)	1.34	1.51	14.58	5646.51	6.77	432.29	356.39	173.11	217.83	4.19	1.47
Maximum	12.40	12.30	54.80	20100.00	41.90	2100.00	1400.00	1030.00	1070.00	32.00	8.71
Minimum	6.12	5.14	0.44	29.00	0.00	45.50	0.00	0.00	0.00	0.00	0.10
Range	6.28	7.16	54.36	20071.00	41.90	2054.50	1400.00	1030.00	1070.00	32.00	8.61
Skewness	1.28	0.28	0.79	0.92	3.70	1.75	1.72	4.62	3.85	7.23	2.64
Kurtosis	1.09	-0.11	-0.35	-0.14	17.59	3.02	2.31	22.07	14.64	54.20	9.98

E.C. = Electrical Conductivity (dS/m); Alk = Alkalinity (mg CaCO3/L); HCO3, CO3, OH reported as mg CaCO3/L.

Parameter	Cr	Fe	V	Ti	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na
							(mg/L)					
Count (N)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Sum	3.63	42.68	1.78	3.61	0.32	0.69	3.56	9.57	18.93	19768.80	2346.78	95334.80
Mean	0.06	0.71	0.03	0.06	0.01	0.01	0.06	0.16	0.32	329.48	39.11	1588.91
SEM	0.03	0.45	0.00	0.02	0.00	0.00	0.00	0.03	0.11	62.31	9.36	225.96
Median	0.01	0.09	0.02	0.02	0.01	0.01	0.05	0.09	0.05	148.00	10.85	1080.00
Variance	0.04	11.99	0.00	0.03	0.00	0.00	0.00	0.04	0.78	232928	5259.35	3063567.55
StDev (sd)	0.20	3.46	0.03	0.18	0.00	0.02	0.03	0.21	0.88	482.63	72.52	1750.30
Maximum	1.36	26.80	0.15	1.26	0.02	0.09	0.25	1.00	6.19	3100.00	413.00	9040.00
Minimum	0.01	0.01	0.02	0.01	0.01	0.01	0.05	0.01	0.00	11.20	0.05	24.70
Range	1.35	26.80	0.14	1.26	0.01	0.08	0.20	0.99	6.19	3088.80	412.95	9015.30
Skewness	5.39	7.50	2.49	5.90	6.15	2.97	4.31	2.17	5.43	3.67	3.51	2.36
Kurtosis	32.62	57.29	5.57	38.70	39.25	9.41	21.09	5.16	34.08	18.07	14.07	6.03

Parameter	K	Li	Sr	B	Ba	P	Mo	Ni	Se	Co	SO4	Si	As
							(mg/L)						
Count (N)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Sum	182003.58	4.32	236.59	15.74	31.90	15.20	4.50	1.13	9.00	0.42	68491.10	402.81	2.17
Mean	3033.39	0.07	3.94	0.26	0.53	0.25	0.08	0.02	0.15	0.01	1141.52	6.71	0.04
SEM	559.43	0.02	0.84	0.03	0.10	0.05	0.01	0.00	0.00	0.00	127.90	0.86	0.00
Median	629.00	0.05	2.43	0.18	0.23	0.13	0.03	0.02	0.15	0.01	838.00	4.53	0.02
Variance	18777452	0.01	41.85	0.07	0.61	0.16	0.00	0.00	0.00	0.00	981523.15	44.75	0.00
StDev (sd)	4333.30	0.12	6.47	0.26	0.78	0.40	0.06	0.01	0.00	0.01	990.72	6.69	0.03
Maximum	15500.00	0.90	46.60	1.48	3.64	2.54	0.23	0.08	0.15	0.04	4320.00	35.00	0.18
Minimum	2.22	0.02	0.14	0.02	0.00	0.05	0.03	0.02	0.15	0.01	34.80	0.05	0.02
Range	15497.78	0.88	46.46	1.46	3.64	2.49	0.21	0.06	0.00	0.04	4285.20	34.95	0.16
Skewness	1.60	6.01	5.20	2.36	2.38	3.97	0.94	3.55		3.80	1.34	2.15	2.11
Kurtosis	1.74	41.61	32.71	7.53	6.14	19.45	-0.43	13.57		15.40	1.82	5.40	4.81

(Concluded). Statistical Parameters of the KCl Liquid Phase Samples.

Parameter	T. Residue g/L	EC50 5min(%)	EC50 15min(%)	Oil mg/L	Benzene (mg/Kg)	Toluene (mg/Kg)	Ethyl Benzene (mg/Kg)	P-Xylene (mg/Kg)	M-Xylene (mg/Kg)	O-Xylene (mg/Kg)
Count (N)	60.00	31.00	31.00	23.00	27.00	27.00	27.00	27.00	27.00	27.00
Sum	3181.07	1475.11	1451.77	762.96	25.63	2.67	5.01	0.67	0.67	5.00
Mean	53.02	47.58	46.83	33.17	0.95	0.10	0.19	0.03	0.03	0.19
SEM	9.42	6.86	7.02	29.83	0.58	0.06	0.15	0.00	0.00	0.16
Median	23.10	38.60	37.10	2.00	0.03	0.03	0.03	0.03	0.03	0.03
Variance	5321.48	1459.07	1528.10	20467.05	9.06	0.11	0.63	0.00	0.00	0.69
StDev (sd)	72.95	38.20	39.09	143.06	3.01	0.33	0.80	0.00	0.00	0.83
Maximum	316.00	100.00	100.00	689.00	14.50	1.72	4.16	0.03	0.03	4.35
Minimum	1.41	1.14	1.06	0.44	0.03	0.03	0.03	0.03	0.03	0.03
Range	314.59	98.86	98.94	688.56	14.48	1.70	4.14	0.00	0.00	4.33
Skewness	2.00	0.42	0.44	4.79	3.98	4.97	5.18			5.20
Kurtosis	3.51	-1.52	-1.58	22.93	16.91	25.23	26.87			27.00

T.Residue = Total Residue (g/L); Microtox Analysis = EC50 (5 or 15 minutes); Trout (LC50(%)) = Concentration of solution lethal to 50% of the trout in 96 hours of exposure; Trout Survival = Number of 3 possible fish that survive for 96 hours.

Parameter	Trout LC50(%)	Trout Survival
Count (N)	26.00	25.00
Sum	815.20	11.00
Mean	31.35	0.44
SEM	6.68	0.19
Median	15.50	0.00
Variance	1160.48	0.92
StDev (sd)	34.07	0.96
Maximum	100.00	3.00
Minimum	3.30	0.00
Range	96.70	3.00
Skewness	1.19	2.02
Kurtosis	-0.22	2.77

Statistical Parameters of the NaCl Liquid Phase Samples.

Parameter	pH		E.C.	Cl	NH4	Alk.	HCO3	CO3	OH	NO3-N	Al
	Lab	Field	(mg/L)								
Count (N)	9.00	7.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Sum	75.67	53.24	354.26	360653.10	8.11	1082.40	1019.50	59.49	4.18	4.43	12.30
Mean	8.41	7.61	39.36	40072.57	0.90	120.27	113.28	6.61	0.46	0.49	1.37
SEM	0.24	0.34	20.90	17968.50	0.44	24.87	25.57	4.38	0.33	0.11	0.43
Median	8.57	8.02	5.78	6620.00	0.20	116.00	89.40	1.89	0.19	0.45	1.29
Variance	0.51	0.81	3932.64	2905804398.37	1.76	5565.86	5882.79	173.04	0.97	0.11	1.65
StDev (sd)	0.72	0.90	62.71	53905.51	1.32	74.60	76.70	13.15	0.99	0.33	1.28
Maximum	9.79	8.51	149.00	117000.00	3.77	302.00	301.00	41.40	3.08	0.84	3.91
Minimum	7.30	6.10	0.73	76.10	0.00	41.40	39.80	0.25	0.01	0.03	0.10
Range	2.49	2.41	148.27	116923.90	3.77	260.60	261.20	41.15	3.07	0.81	3.81
Skewness	0.41	-0.78	1.51	0.85	1.52	2.05	2.14	2.91	2.94	-0.19	1.12
Kurtosis	0.95	-0.77	0.52	-1.61	1.72	5.28	5.35	8.58	8.73	-1.92	0.64

E.C. = Electrical Conductivity (dS/m); Alk = Alkalinity (mg CaCO3/L); HCO3, CO3, OH reported as mg CaCO3/L.

Parameter	Cr	Fe	V	Ti	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na
	(mg/L)											
Count (N)	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Sum	0.09	1.05	0.14	0.08	0.05	0.05	0.45	2.02	5.05	4243.00	676.00	194160.00
Mean	0.01	0.12	0.02	0.01	0.01	0.01	0.05	0.22	0.56	471.44	75.11	21573.33
SEM	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.11	0.34	101.35	24.32	10842.56
Median	0.01	0.01	0.02	0.01	0.01	0.01	0.05	0.01	0.04	315.00	82.00	3740.00
Variance	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.10	1.05	92449.78	5321.37	1058050019.00
StDev (sd)	0.00	0.33	0.00	0.01	0.00	0.00	0.00	0.32	1.03	304.06	72.95	32527.68
Maximum	0.01	0.99	0.02	0.02	0.01	0.01	0.05	0.83	2.93	991.00	202.00	79600.00
Minimum	0.01	0.01	0.02	0.01	0.01	0.01	0.05	0.01	0.00	133.00	0.05	404.00
Range	0.00	0.99	0.00	0.01	0.00	0.00	0.00	0.82	2.93	858.00	201.95	79196.00
Skewness		3.00		0.54				1.25	1.99	0.49	0.62	1.43
Kurtosis		9.00		-1.81				0.06	3.42	-1.09	-0.77	0.33

Parameter	K	Li	Sr	B	Ba	P	Mo	Ni	Se	Co	SO4	Si	As
	(mg/L)												
Count (N)	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Sum	9993.00	1.12	56.13	0.55	0.94	0.45	0.23	0.14	1.35	0.05	12651.00	43.10	0.14
Mean	1110.33	0.12	6.24	0.06	0.10	0.05	0.03	0.02	0.15	0.01	1405.67	4.79	0.02
SEM	709.10	0.04	2.02	0.02	0.03	0.00	0.00	0.00	0.00	0.00	139.80	0.69	0.00
Median	23.80	0.07	2.58	0.02	0.13	0.05	0.03	0.02	0.15	0.01	1480.00	4.99	0.02
Variance	4525364.70	0.01	36.63	0.01	0.01	0.00	0.00	0.00	0.00	0.00	175896.50	4.27	0.00
StDev (sd)	2127.29	0.11	6.05	0.07	0.08	0.00	0.00	0.00	0.00	0.00	419.40	2.07	0.00
Maximum	4990.00	0.35	15.80	0.19	0.22	0.05	0.03	0.02	0.15	0.01	2010.00	7.44	0.02
Minimum	8.57	0.02	0.88	0.02	0.01	0.05	0.03	0.02	0.15	0.01	681.00	1.40	0.02
Range	4981.43	0.33	14.92	0.17	0.20	0.00	0.00	0.00	0.00	0.00	1329.00	6.04	0.00
Skewness	1.62	1.09	0.93	1.56	0.02						-0.25	-0.18	
Kurtosis	0.76	0.76	-0.88	0.61	-1.76						-0.52	-0.80	

(Concluded). Statistical Parameters of the NaCl Liquid Phase Samples.

Parameter	T.Residue	----- EC50	------	Oil	Benzene	Toluene	Ethyl Benzene	P-Xylene	M-Xylene	O-Xylene
	g/L	5min(%)	15min(%)	mg/L	-------------	-------------	(mg/Kg)	-------------	-------------	-------------
Count (N)	9.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Sum	590.08	303.20	316.00	5.88	17.57	0.10	0.10	0.10	0.10	0.10
Mean	65.56	75.80	79.00	1.47	4.39	0.03	0.03	0.03	0.03	0.03
SEM	30.21	20.61	21.00	0.45	3.28	0.00	0.00	0.00	0.00	0.00
Median	14.20	94.35	100.00	1.56	1.82	0.03	0.03	0.03	0.03	0.03
Variance	8215.59	1698.46	1764.00	0.81	43.05	0.00	0.00	0.00	0.00	0.00
StDev (sd)	90.64	41.21	42.00	0.90	6.56	0.00	0.00	0.00	0.00	0.00
Maximum	223.00	100.00	100.00	2.33	13.90	0.03	0.03	0.03	0.03	0.03
Minimum	2.24	14.50	16.00	0.44	0.03	0.03	0.03	0.03	0.03	0.03
Range	220.76	85.50	84.00	1.89	13.88	0.00	0.00	0.00	0.00	0.00
Skewness	1.32	-1.90	-2.00	-0.27	1.63					
Kurtosis	0.04	3.64	4.00	-3.91	2.51					

T.Residue = Total Residue (g/L); Microtox Analysis = EC50 (5 or 15 minutes); Trout (LC50(%)) = Concentration of solution lethal to 50% of the trout in 96 hours of exposure; Trout Survival = Number of 3 possible fish that survive for 96 hours.

Parameter	------ Trout	-----
	LC50(%)	Survival
Count (N)	4.00	3.00
Sum	256.00	6.00
Mean	64.00	2.00
SEM	22.64	1.00
Median	75.00	3.00
Variance	2050.67	3.00
StDev (sd)	45.28	1.73
Maximum	100.00	3.00
Minimum	6.00	0.00
Range	94.00	3.00
Skewness	-0.75	-1.73
Kurtosis	-1.84	

Statistical Parameters of the Other (Polymer, K2CO3, SAPP-Polymer, K-Acetate, Metal-OH, SAPP-K) Liquid Phase Samples.

Parameter	pH		E.C.	Cl	NH4	Alk.	HCO3	CO3	OH	NO3-N	Al
	Lab	Field					(mg/L)				
Count (N)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Sum	180.67	184.29	72.51	5204.90	34.88	24314.00	17010.00	7289.46	38.15	1.94	111.77
Mean	9.03	9.21	3.63	260.25	1.74	1215.70	850.50	364.47	1.91	0.10	5.59
SEM	0.17	0.21	0.57	68.98	0.52	285.75	163.01	159.46	0.70	0.02	3.38
Median	9.20	9.33	3.56	109.00	1.08	714.50	678.50	57.45	0.81	0.07	0.86
Variance	0.60	0.88	6.59	95153.20	5.31	1633070.85	531439.84	508524.84	9.79	0.00	228.37
StDev (sd)	0.77	0.94	2.57	308.47	2.31	1277.92	729.00	713.11	3.13	0.07	15.11
Maximum	10.40	11.20	10.70	1180.00	8.38	5080.00	2650.00	2430.00	13.50	0.26	61.50
Minimum	7.91	7.93	0.41	27.10	0.00	123.00	120.00	2.68	0.04	0.01	0.10
Range	2.49	3.27	10.29	1152.90	8.38	4957.00	2530.00	2427.32	13.46	0.25	61.40
Skewness	0.08	0.32	0.94	1.70	1.79	1.87	1.33	2.46	2.96	1.04	3.32
Kurtosis	-1.45	-0.51	1.49	2.95	2.85	3.42	1.03	5.22	10.24	0.19	10.91

E.C. = Electrical Conductivity (dS/m); Alk = Alkalinity (mg CaCO3/L); HCO3, CO3, OH reported as mg CaCO3/L.

Parameter	Cr	Fe	V	Ti	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na
							(mg/L)					
Count (N)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Sum	0.31	56.99	1.31	5.51	0.12	0.30	1.44	1.58	2.40	1013.32	149.78	11312.10
Mean	0.02	2.85	0.07	0.28	0.01	0.02	0.07	0.08	0.12	50.67	7.49	565.61
SEM	0.00	1.16	0.01	0.16	0.00	0.00	0.01	0.01	0.04	12.54	2.05	62.11
Median	0.01	0.95	0.02	0.03	0.01	0.01	0.05	0.06	0.07	22.90	5.50	627.00
Variance	0.00	26.91	0.00	0.52	0.00	0.00	0.00	0.00	0.03	3143.61	83.66	77147.45
StDev (sd)	0.02	5.19	0.06	0.72	0.00	0.02	0.05	0.06	0.16	56.07	9.15	277.75
Maximum	0.07	21.40	0.20	3.21	0.02	0.06	0.20	0.20	0.68	208.00	42.20	1030.00
Minimum	0.01	0.01	0.02	0.01	0.01	0.01	0.05	0.01	0.00	2.63	0.41	89.10
Range	0.06	21.40	0.19	3.21	0.01	0.06	0.15	0.19	0.68	205.37	41.79	940.90
Skewness	2.98	2.94	0.81	3.89	2.89	1.90	2.11	0.73	2.43	1.52	3.09	-0.16
Kurtosis	8.58	9.02	-0.79	16.08	7.04	2.98	3.21	-0.37	7.12	2.05	11.58	-1.29

Parameter	K	Li	Sr	B	Ba	P	Mo	Ni	Se	Co	SO4	Si	As
							(mg/L)						
Count (N)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Sum	8056.07	1.26	18.42	9.66	7.34	25.74	3.83	0.56	3.16	0.18	9506.20	327.04	2.70
Mean	402.80	0.06	0.92	0.48	0.37	1.29	0.19	0.03	0.16	0.01	475.31	16.35	0.14
SEM	126.49	0.01	0.19	0.11	0.09	0.95	0.06	0.00	0.01	0.00	98.50	7.86	0.02
Median	233.00	0.07	0.50	0.33	0.20	0.28	0.12	0.02	0.15	0.01	372.00	5.30	0.13
Variance	319975.35	0.00	0.74	0.24	0.16	18.13	0.07	0.00	0.00	0.00	194050.11	1234.53	0.01
StDev (sd)	565.66	0.04	0.86	0.49	0.40	4.26	0.26	0.02	0.03	0.01	440.51	35.14	0.10
Maximum	2400.00	0.13	2.52	1.81	1.63	19.30	1.13	0.07	0.31	0.03	1560.00	146.00	0.48
Minimum	3.32	0.02	0.13	0.05	0.03	0.05	0.03	0.02	0.15	0.01	35.70	0.43	0.02
Range	2396.68	0.11	2.39	1.76	1.60	19.25	1.11	0.06	0.16	0.03	1524.30	145.58	0.47
Skewness	2.48	0.26	0.79	1.52	1.86	4.41	2.95	1.39	4.47	2.22	1.05	3.29	2.24
Kurtosis	7.93	-1.21	-0.90	1.72	3.93	19.60	9.64	0.54	20.00	3.81	0.22	10.77	6.72

(Concluded). Statistical Parameters of the Other (Polymer, K2CO3, SAPP-Polymer, K-Acetate, Metal-OH, SAPP-K) Liquid Phase Samples.

Parameter	T. Residue	----- EC50 ------		Oil	Benzene	Toluene	Ethyl Benzene	P-Xylene	M-Xylene	O-Xylene
	g/L	5min(%)	15min(%)	mg/L	(mg/Kg)					
Count (N)	20.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Sum	1349.41	662.36	637.60	151.79	0.23	0.23	0.23	0.23	0.23	0.23
Mean	67.47	73.60	70.84	16.87	0.03	0.03	0.03	0.03	0.03	0.03
SEM	12.53	13.24	13.54	15.15	0.00	0.00	0.00	0.00	0.00	0.00
Median	61.80	96.40	100.00	1.50	0.03	0.03	0.03	0.03	0.03	0.03
Variance	3141.49	1576.61	1650.51	2065.92	0.00	0.00	0.00	0.00	0.00	0.00
StDev (sd)	56.05	39.71	40.63	45.45	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	184.00	100.00	100.00	138.00	0.03	0.03	0.03	0.03	0.03	0.03
Minimum	0.59	4.06	3.20	0.44	0.03	0.03	0.03	0.03	0.03	0.03
Range	183.41	95.94	96.80	137.56	0.00	0.00	0.00	0.00	0.00	0.00
Skewness	0.66	-1.20	-1.00	2.99						
Kurtosis	-0.61	-0.34	-0.87	8.97						

T.Residue = Total Residue (g/L); Microtox Analysis = EC50 (5 or 15 minutes); Trout (LC50(%)) = Concentration of solution lethal to 50% of the trout in 96 hours of exposure; Trout Survival = Number of 3 possible fish that survive for 96 hours.

Parameter	------ Trout -----	
	LC50(%)	Survival
Count (N)	9.00	8.00
Sum	447.00	6.00
Mean	49.67	0.75
SEM	11.57	0.49
Median	30.00	0.00
Variance	1204.25	1.93
StDev (sd)	34.70	1.39
Maximum	100.00	3.00
Minimum	4.00	0.00
Range	96.00	3.00
Skewness	0.25	1.44
Kurtosis	-1.76	-0.00

APPENDIX 4: STATISTICAL PARAMETERS FOR EC, CL, AL, CR, FE, AND OIL CONTENT IN THE FRESHWATER GEL LIQUID PHASE SAMPLES FOR THE DIFFERENT ERCB REGIONS

Statistical Parameters for EC (dS/m) in the Freshwater Gel Liquid Phase Samples for the Different ERCB Regions.

	ERCB Region							
Parameter	3	4	5	6	7	8	9	10
Count (N)	12.00	9.00	7.00	17.00	31.00	19.00	35.00	27.00
Mean	6.18	3.29	2.10	2.73	3.36	3.60	2.57	3.94
Median	2.81	3.16	0.96	1.65	2.84	2.21	2.70	3.89
Std. Dev.	5.08	2.24	2.01	2.82	2.24	2.88	1.64	2.16
Maximum	13.40	8.30	5.56	10.30	12.30	10.70	5.94	8.33
Minimum	1.36	1.16	0.48	0.34	0.62	1.50	0.14	0.39

Statistical Parameters for Cl (mg/L) in the Freshwater Gel Liquid Phase Samples for the Different ERCB Regions.

	ERCB Region							
Parameter	3	4	5	6	7	8	9	10
Count (N)	12.00	9.00	7.00	17.00	31.00	19.00	35.00	27.00
Mean	3406.67	112.52	284.00	415.60	435.32	299.91	197.15	308.77
Median	357.50	68.60	236.00	39.40	207.00	164.00	108.00	177.00
Std. Dev.	3917.88	80.18	144.91	1496.28	599.35	275.28	265.24	306.51
Maximum	9760.00	238.00	570.00	6220.00	3230.00	1050.00	983.00	1230.00
Minimum	120.00	36.80	134.00	5.21	47.70	55.50	7.04	46.80

Statistical Parameters for Al (mg/L) in the Freshwater Gel Liquid Phase Samples for the Different ERCB Regions.

	ERCB Region							
Parameter	3	4	5	6	7	8	9	10
Count (N)	12.00	9.00	7.00	17.00	31.00	19.00	35.00	27.00
Mean	2.26	1.78	0.57	1.00	2.39	8.55	0.92	2.24
Median	1.41	0.84	0.41	0.74	1.31	1.29	0.70	1.00
Std. Dev.	2.68	2.57	0.34	1.05	2.31	28.97	0.77	2.77
Maximum	8.31	8.41	0.95	3.94	8.63	128.00	3.21	10.20
Minimum	0.10	0.10	0.10	0.10	0.10	0.24	0.10	0.22

Statistical Parameters for Cr (mg/L) in the Freshwater Gel Liquid Phase Samples for the Different ERCB Regions.

	ERCB Region							
Parameter	3	4	5	6	7	8	9	10
Count (N)	12.00	9.00	7.00	17.00	31.00	19.00	35.00	27.00
Mean	0.02	0.01	0.64	0.35	0.16	0.24	0.10	0.32
Median	0.01	0.01	0.12	0.25	0.01	0.01	0.01	0.03
Std. Dev.	0.02	0.00	1.31	0.44	0.44	0.37	0.21	0.44
Maximum	0.06	0.02	3.59	1.60	2.23	1.03	0.92	1.34
Minimum	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Statistical Parameters for Fe (mg/L) in the Freshwater Gel Liquid Phase Samples for the Different ERCB Regions.

	ERCB Region							
Parameter	3	4	5	6	7	8	9	10
Count (N)	12.00	9.00	7.00	17.00	31.00	19.00	35.00	27.00
Mean	2.19	1.61	1.54	0.93	1.46	3.82	0.96	1.43
Median	0.82	1.43	0.58	0.67	1.18	0.85	0.25	1.12
Std. Dev.	3.45	1.05	1.66	0.66	1.69	9.33	1.97	1.10
Maximum	10.00	3.25	3.88	2.77	6.82	40.60	9.49	4.41
Minimum	0.03	0.25	0.18	0.33	0.01	0.05	0.01	0.04

Statistical Parameters for Oil Content (mg/L) in the Freshwater Gel Liquid Phase Samples for the Different ERCB Region.

	ERCB Region							
Parameter	3	4	5	6	7	8	9	10
Count (N)	5.00	5.00	2.00	5.00	12.00	8.00	15.00	10.00
Mean	4663.27	94.79	7.58	11.93	242.06	2.88	21.40	602.04
Median	3.56	7.88	7.58	2.00	21.05	2.59	1.89	6.83
Std. Dev.	10418.25	151.76	5.69	19.79	496.66	2.48	43.06	1827.14
Maximum	23300.00	354.00	11.60	46.90	1660.00	8.57	141.00	5800.00
Minimum	1.78	2.00	3.55	0.89	1.00	0.75	0.59	0.33

APPENDIX 5: STATISTICAL PARAMETERS FOR THE CHEMICAL AND PHYSICAL PROPERTIES OF THE SOLID PHASE SAMPLES

Statistical Parameters of the Chemical and Physical Properties for the Freshwater Gel Solid Phase Samples.

Parameter	H2O	pH		TC	TOC	TIC	CaCO3	ANC	Na	K	Ca	Mg	CEC
	(%)	H2O	CaCl2	(%)					(cmol(+)/kg)				
Count	390.00	390.00	390.00	390.00	390.00	390.00	390.00	69.00	69.00	69.00	69.00	69.00	69.00
Mean	161.56	8.75	8.62	3.74	2.54	1.20	10.04	15.25	14.41	1.59	30.94	1.74	21.60
Median	118.00	8.60	8.50	2.84	1.91	0.69	5.76	10.90	12.50	0.98	28.40	1.52	21.70
StDev	146.68	0.68	0.64	2.81	2.44	1.26	10.47	10.97	8.00	3.11	17.85	0.89	6.82
Maximum	990.00	12.30	12.00	26.00	24.60	9.61	80.10	55.50	44.10	25.90	110.00	5.18	37.30
Minimum	2.20	7.30	7.30	0.98	0.00	0.07	0.56	4.10	3.50	0.49	6.85	0.30	1.30

TC = Total Carbon; TIC = Inorganic Carbon; TOC = Total Organic Carbon; CaCO3 = CaCO3 Equivalent (g CaCO3eq/ 100 g soil); ANC = Acid Neutralizing Capacity; CEC = Cation Exchange Capacity.

Parameter	Oil	S	Si	C	EC50(%)	
	(%)				5 min	15 min
Count	69.00	69.00	69.00	69.00	390.00	390.00
Mean	0.42	25.65	45.03	29.32	64.24	61.84
Median	0.15	23.00	45.00	29.00	83.55	76.80
StDev	1.06	10.86	8.72	9.78	39.40	40.43
Maximum	8.24	57.00	82.00	59.00	100.00	100.00
Minimum	0.03	8.00	28.00	7.00	0.32	0.24

Statistical Parameters of the Chemical and Physical Properties for the Invert Solid Phase Samples.

Parameter	H_2O (%)	pH		TC	TOC	TIC	$CaCO_3$	ANC	Na	K	Ca	Mg	CEC
		H_2O	$CaCl_2$	(%)					(cmol(+)/kg)				
Count	86.00	86.00	86.00	86.00	86.00	86.00	86.00	18.00	18.00	18.00	18.00	18.00	18.00
Mean	105.61	8.93	9.03	10.47	8.97	1.49	12.46	20.25	9.27	1.26	69.97	1.89	14.79
Median	41.20	8.80	8.80	10.90	9.31	0.86	7.16	15.55	7.66	1.28	51.35	1.35	12.65
StDev	120.87	1.29	0.92	4.80	4.52	1.65	13.72	14.06	3.79	0.50	62.96	1.35	6.60
Maximum	491.00	12.50	12.40	27.00	24.80	7.27	60.60	54.70	16.80	2.12	304.00	4.81	31.00
Minimum	11.40	1.00	7.80	1.08	0.54	0.24	1.98	5.58	4.56	0.42	22.50	0.68	8.50

TC = Total Carbon; TIC = Inorganic Carbon; TOC = Total Organic Carbon; $CaCO_3$ = $CaCO_3$ Equivalent (g $CaCO_3$eq/ 100 g soil); ANC = Acid Neutralizing Capacity; CEC = Cation Exchange Capacity.

Parameter	Oil	S	Si	C	EC50 (%)	
	(%)				5 min	15 min
Count	18.00	18.00	18.00	18.00	86.00	86.00
Mean	6.22	48.06	35.39	16.56	10.20	9.32
Median	6.83	53.00	34.50	9.50	5.39	4.85
StDev	3.47	20.05	11.45	15.09	17.21	15.59
Maximum	11.80	77.00	68.00	62.00	100.00	100.00
Minimum	0.12	9.00	16.00	2.00	0.25	0.03

Statistical Parameters of the Chemical and Physical Properties for the KCl Solid Phase Samples.

Parameter	H_2O (%)	pH H_2O	pH $CaCl_2$	TC	TOC	TIC	$CaCO_3$	ANC	Na	K	Ca	Mg	CEC
				(%)					(cmol(+)/kg)				
Count	122.00	122.00	122.00	122.00	122.00	122.00	122.00	24.00	24.00	24.00	24.00	24.00	24.00
Mean	128.75	8.56	8.57	3.44	2.45	0.99	8.25	13.92	18.69	33.90	36.90	2.26	22.11
Median	98.95	8.40	8.40	2.57	1.85	0.59	4.95	11.20	10.84	26.85	21.75	1.48	21.05
StDev	109.58	0.74	0.69	2.63	2.03	1.01	8.44	8.72	19.91	29.76	54.70	2.50	5.17
Maximum	679.00	12.50	12.30	20.60	16.90	6.58	54.90	38.40	82.30	104.00	280.00	11.70	31.30
Minimum	13.00	7.50	7.60	0.90	0.52	0.13	1.12	3.95	2.48	0.57	8.10	0.65	13.60

TC = Total Carbon; TIC = Inorganic Carbon; TOC = Total Organic Carbon; $CaCO_3$ = $CaCO_3$ Equivalent (g $CaCO_3$eq/ 100 g soil); ANC = Acid Neutralizing Capacity; CEC = Cation Exchange Capacity.

Parameter	Oil	S	Si	C	EC50(%) 5 min	EC50(%) 15 min
	(%)					
Count	24.00	24.00	24.00	24.00	122.00	122.00
Mean	0.51	29.75	39.67	30.58	67.59	67.99
Median	0.17	31.00	41.00	28.50	100.00	100.00
StDev	0.85	7.94	6.51	10.38	38.52	38.86
Maximum	3.88	54.00	48.00	62.00	100.00	100.00
Minimum	0.05	9.00	23.00	14.00	0.32	0.24

Statistical Parameters of the Chemical and Physical Properties for the NaCl Solid Phase Samples.

Parameter	H2O	pH		TC	TOC	TIC	CaCO3	ANC	Na	K	Ca	Mg	CEC
	(%)	H2O	CaCl2	(%)					(cmol(+)/kg)				
Count	11.00	11.00	11.00	11.00	11.00	11.00	11.00	3.00	3.00	3.00	3.00	3.00	3.00
Mean	129.45	7.45	8.20	5.69	2.98	2.71	22.62	28.77	314.00	9.97	40.43	1.46	16.33
Median	166.00	7.90	8.20	4.68	2.83	1.66	13.90	22.60	237.00	0.84	38.40	1.56	14.90
StDev	66.99	1.83	0.20	4.06	1.41	2.75	22.88	27.56	350.89	16.13	9.91	0.49	7.65
Maximum	197.00	8.50	8.60	13.80	5.48	8.36	69.70	58.90	697.00	28.60	51.20	1.89	24.60
Minimum	37.40	2.00	7.90	1.29	1.02	0.27	2.25	4.82	8.01	0.48	31.70	0.93	9.50

TC = Total Carbon; TIC = Inorganic Carbon; TOC = Total Organic Carbon; CaCO3 = CaCO3 Equivalent (g CaCO3eq/ 100 g soil); ANC = Acid Neutralizing Capacity; CEC = Cation Exchange Capacity.

Parameter	Oil	S	Si	C	EC50(%)	
	(%)				5 min	15 min
Count	3.00	3.00	3.00	3.00	11.00	11.00
Mean	0.37	30.33	31.67	38.00	37.25	39.50
Median	0.37	26.00	30.00	34.00	25.40	28.50
StDev	0.34	23.80	7.64	21.28	32.48	31.96
Maximum	0.70	56.00	40.00	61.00	100.00	100.00
Minimum	0.03	9.00	25.00	19.00	3.35	3.26

Statistical Parameters of the Chemical and Physical Properties for the Other (Polymer, K_2CO_3, SAPP-Polymer, K-Acetate, Metal-OH, SAPP-K) Solid Phase Samples.

Parameter	H_2O	pH		TC	TOC	TIC	$CaCO_3$	ANC	Na	K	Ca	Mg	CEC
	(%)	H_2O	$CaCl_2$	(%)					(cmol(+)/kg)				
Count	42.00	42.00	42.00	41.00	41.00	41.00	41.00	8.00	8.00	8.00	8.00	8.00	8.00
Mean	104.18	8.86	8.65	2.14	1.59	0.56	4.63	8.04	11.09	4.60	22.96	1.59	22.29
Median	79.95	8.78	8.60	2.01	1.50	0.51	4.23	7.42	10.39	1.17	21.95	1.41	22.15
StDev	85.87	0.59	0.47	0.64	0.50	0.21	1.78	2.42	4.58	6.18	8.25	0.84	3.77
Maximum	427.00	10.00	9.80	3.66	2.84	1.09	9.08	13.30	19.20	18.40	39.50	2.79	27.20
Minimum	13.70	7.60	7.30	1.30	0.88	0.19	1.61	5.10	4.70	0.70	10.10	0.66	17.90

TC = Total Carbon; TIC = Inorganic Carbon; TOC = Total Organic Carbon; $CaCO_3$ = $CaCO_3$ Equivalent (g $CaCO_3$eq/ 100 g soil); ANC = Acid Neutralizing Capacity; CEC = Cation Exchange Capacity.

Parameter	Oil	S	Si	C	EC50(%)	
	(%)				5 min	15 min
Count	8.00	8.00	8.00	8.00	41.00	41.00
Mean	0.13	37.38	38.88	23.75	63.86	62.38
Median	0.11	31.50	42.50	26.50	100.00	100.00
StDev	0.07	24.32	13.72	12.59	41.80	42.97
Maximum	0.22	88.00	49.00	42.00	100.00	100.00
Minimum	0.05	9.00	6.00	6.00	3.78	3.11

APPENDIX 6: STATISTICAL PARAMETERS OF THE SATURATED PASTE EXTRACT DATA FOR THE SOLID PHASE SAMPLES

Statistical Parameters of the Saturated Paste Extract Data for the Freshwater Gel Solid Phase Samples.

Parameter	Satn	E.C.	pH	NO3	NH4	Alk.	HC03	C03	OH	Cl	Al	Cr
	(%)	(dS/m)						(mg/L)				
Count (N)	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00
Mean	89.98	8.50	8.17	47.83	1.23	281.87	234.53	39.13	8.22	1114.91	1.62	0.06
Median	80.75	7.13	7.98	0.48	0.53	184.50	175.00	1.58	0.05	410.50	1.82	0.01
StDev (sd)	36.40	6.81	0.86	222.73	2.84	433.51	257.44	202.40	103.15	3252.56	1.07	0.30
Maximum	224.00	98.20	12.60	2900.00	27.20	5790.00	3990.00	2990.00	1950.00	45400.00	10.50	4.23
Minimum	27.00	1.65	7.00	0.00	0.00	30.10	6.96	0.07	0.01	0.00	0.10	0.01

Sat'n = Percent Saturation; E.C. = Electrical Conductivity (dS/m); Alk = Alkalinity (mg CaCO3/L); HCO3, CO3, OH reported as mg CaCO3/L; SAR = Sodium Adsorption Ratio.

Parameter	Fe	V	Ti	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na	K	Li
								(mg/L)					
Count (N)	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00
Mean	0.26	0.03	0.03	0.01	0.03	0.05	0.57	0.06	385.76	19.80	2127.49	217.84	0.09
Median	0.01	0.02	0.01	0.01	0.01	0.05	0.20	0.02	423.00	11.25	1785.00	59.25	0.05
StDev (sd)	1.92	0.08	0.21	0.10	0.13	0.09	6.78	0.16	296.81	23.75	1745.38	1504.53	0.18
Maximum	24.40	1.12	4.09	1.97	2.03	1.84	134.00	1.99	2950.00	169.00	21400.00	27400.00	2.78
Minimum	0.01	0.02	0.01	0.01	0.01	0.05	0.01	0.00	0.50	0.05	261.00	7.66	0.02

Parameter	Sr	B	Ba	P	Mo	Ni	Se	Co	S04	Si	As	SAR
						(mg/L)						
Count (N)	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00
Mean	4.19	0.69	0.11	0.65	0.72	0.03	0.15	0.01	1943.01	8.07	0.10	45.50
Median	3.54	0.45	0.06	0.10	0.60	0.02	0.15	0.01	1440.00	5.12	0.06	27.40
StDev (sd)	3.17	0.73	0.35	2.88	0.58	0.15	0.02	0.00	1486.58	8.66	0.12	94.70
Maximum	26.30	4.73	3.61	32.00	6.70	2.88	0.51	0.08	10800.00	67.20	0.86	1530.00
Minimum	0.00	0.02	0.00	0.05	0.03	0.02	0.15	0.01	158.00	1.01	0.02	2.61

Statistical Parameters of the Saturated Paste Extract Data for the Invert Solid Phase Samples.

Parameter	Satn (%)	E.C. (dS/m)	pH	NO3	NH4	Alk.	HC03	C03	OH	Cl	Al	Cr
								(mg/L)				
Count (N)	86.00	86.00	86.00	84.00	84.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00
Mean	63.20	25.26	8.44	2.25	2.17	388.95	275.05	85.64	28.38	11599.88	11.83	0.01
Median	58.00	19.25	8.13	0.72	0.30	215.50	173.00	3.58	0.07	7755.00	7.25	0.01
StDev (sd)	25.87	17.43	1.16	4.67	3.39	530.98	379.94	266.42	173.61	10551.44	10.53	0.01
Maximum	156.00	76.20	12.40	31.30	15.20	3170.00	2730.00	2070.00	1200.00	44800.00	38.80	0.09
Minimum	34.00	1.61	6.90	0.00	0.00	49.40	0.93	0.05	0.00	195.00	0.10	0.01

Sat'n = Percent Saturation; E.C. = Electrical Conductivity (dS/m); Alk = Alkalinity (mg CaCO3/L); HCO3, CO3, OH reported as mg CaCO3/L; SAR = Sodium Adsorption Ratio.

Parameter	Fe	V	Ti	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na	K	Li
								(mg/L)					
Count (N)	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00
Mean	0.04	0.03	0.05	0.01	0.42	0.07	0.29	0.14	5506.17	48.71	2715.32	275.47	0.14
Median	0.01	0.02	0.05	0.01	0.09	0.05	0.27	0.01	2075.00	21.20	2740.00	195.00	0.08
StDev (sd)	0.12	0.05	0.04	0.00	0.77	0.08	0.19	0.69	5890.60	66.46	1567.58	252.51	0.20
Maximum	0.74	0.28	0.21	0.02	4.28	0.56	0.99	6.03	23000.00	376.00	7810.00	1010.00	1.32
Minimum	0.01	0.02	0.01	0.01	0.01	0.05	0.01	0.00	0.65	0.05	98.80	8.49	0.02

Parameter	Sr	B	Ba	P	Mo	Ni	Se	Co	S04	Si	As	SAR
						(mg/L)						
Count (N)	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00
Mean	77.42	0.97	1.04	0.81	0.32	0.31	0.17	0.05	610.24	9.43	0.16	25.60
Median	17.05	0.44	0.24	0.43	0.32	0.09	0.15	0.01	413.00	6.19	0.11	11.05
StDev (sd)	91.21	1.48	1.95	1.30	0.19	0.58	0.09	0.07	534.97	10.75	0.16	47.29
Maximum	344.00	9.53	11.40	8.68	0.86	2.96	0.78	0.35	2500.00	48.90	1.23	353.00
Minimum	0.05	0.02	0.00	0.05	0.03	0.02	0.15	0.01	39.90	0.43	0.02	0.85

Statistical Parameters of the Saturated Paste Extract Data for the KCl Solid Phase Samples.

Parameter	Satn	E.C.	pH	NO3	NH4	Alk.	HC03	C03	OH	Cl	Al	Cr	Fe
	(%)	(dS/m)		(mg/L)									
Count	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00
Mean	74.84	41.08	7.93	1.48	0.94	299.51	240.98	28.66	29.83	17088.55	2.63	0.03	0.06
Median	66.50	30.15	7.70	0.60	0.44	145.00	138.50	0.71	0.03	10800.00	2.34	0.01	0.01
StDev (sd)	55.55	36.22	0.93	7.01	2.17	566.39	422.80	150.03	222.94	20000.57	1.92	0.09	0.39
Maximum	640.00	162.00	12.70	77.00	22.60	3680.00	3090.00	1440.00	2230.00	87500.00	10.40	0.78	4.17
Minimum	33.50	2.04	6.80	0.00	0.00	0.00	0.00	0.00	0.00	12.70	0.10	0.01	0.01

Sat'n = Percent Saturation; E.C. = Electrical Conductivity (ds/m); Alk = Alkalinty (mg CaCO3/L); HCO3, CO3, OH reported as mg CaCO3/L; SAR = Sodium Adsorption Ratio.

Parameter	V	Ti	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na	K	Li	Sr
	(mg/L)												
Count	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00
Mean	0.02	0.02	0.01	0.01	0.05	0.28	0.12	919.42	56.81	4175.35	12594.05	0.14	12.10
Median	0.02	0.01	0.01	0.01	0.05	0.22	0.04	665.50	38.10	2500.00	5730.00	0.06	7.68
StDev (sd)	0.00	0.02	0.00	0.03	0.00	0.28	0.23	843.72	89.73	5875.42	18023.66	0.16	11.32
Maximum	0.02	0.12	0.01	0.27	0.05	1.39	1.40	6430.00	892.00	44400.00	84400.00	0.85	68.50
Minimum	0.02	0.01	0.01	0.01	0.05	0.01	0.00	1.60	0.05	107.00	29.30	0.02	0.21

Parameter	B	Ba	P	Mo	Ni	Se	Co	S04	Si	As	SAR
	(mg/L)										
Count	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00
Mean	0.25	0.55	0.15	0.40	0.02	0.15	0.01	1530.13	5.84	0.05	45.78
Median	0.07	0.19	0.05	0.33	0.02	0.15	0.01	1250.00	4.49	0.02	22.70
StDev (sd)	0.45	0.94	0.26	0.39	0.01	0.00	0.00	1214.16	5.81	0.08	63.09
Maximum	2.62	5.47	1.88	2.42	0.13	0.15	0.01	6730.00	35.60	0.78	399.00
Minimum	0.02	0.00	0.05	0.03	0.02	0.15	0.01	23.30	0.05	0.02	2.48

Statistical Parameters of the Saturated Paste Extract Data for the NaCl Solid Phase Samples.

Parameter	Satn (%)	E.C. (dS/m)	pH	NO3	NH4	Alk.	HCO3	CO3	OH	Cl	Al	Cr	Fe	V
									(mg/L)					
Count (N)	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00
Mean	58.41	92.53	7.62	3.16	0.62	487.27	485.14	1.73	0.02	117651.36	1.51	0.08	0.01	0.02
Median	57.00	127.00	7.70	3.90	0.59	281.00	280.00	1.16	0.03	180000.00	0.10	0.01	0.01	0.02
StDev (sd)	11.45	62.78	0.28	1.67	0.46	485.43	483.76	1.55	0.02	88822.68	1.78	0.10	0.01	0.00
Maximum	81.50	157.00	8.13	4.90	1.63	1480.00	1470.00	5.82	0.07	190000.00	4.31	0.28	0.04	0.02
Minimum	45.00	5.15	7.25	0.14	0.00	91.00	90.50	0.43	0.01	158.00	0.10	0.01	0.01	0.02

Sat'n = Percent Saturation; E.C. = Electrical Conductivity (ds/m); Alk = Alkalinity (mg CaCO3/L); HCO3, CO3, OH reported as mg CaCO3/L; SAT = Sodium Adsorption Ratio.

Parameter	Ti	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na	K	Li	Sr	B
							(mg/L)						
Count (N)	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00
Mean	0.02	0.01	0.01	0.05	0.84	0.06	688.36	51.22	68936.36	5959.20	0.43	9.71	0.27
Median	0.01	0.01	0.01	0.05	0.57	0.00	601.00	18.90	103000.00	430.00	0.16	12.30	0.11
StDev (sd)	0.02	0.00	0.01	0.00	0.94	0.10	330.85	71.14	55634.53	6701.70	0.49	4.73	0.29
Maximum	0.05	0.01	0.04	0.05	2.23	0.28	1330.00	198.00	151000.00	14000.00	1.33	14.50	0.82
Minimum	0.01	0.01	0.01	0.05	0.01	0.00	316.00	7.31	1070.00	40.70	0.02	2.97	0.02

Parameter	Ba	P	Mo	Ni	Se	Co	SO4	Si	As	SAR
					(mg/L)					
Count (N)	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00
Mean	0.04	0.24	0.11	0.05	0.15	0.01	806.00	4.49	0.03	806.06
Median	0.00	0.27	0.03	0.02	0.15	0.01	694.00	2.94	0.02	1040.00
StDev (sd)	0.05	0.15	0.14	0.08	0.00	0.00	289.30	4.32	0.03	731.11
Maximum	0.11	0.50	0.42	0.25	0.15	0.01	1300.00	15.20	0.09	2270.00
Minimum	0.00	0.05	0.03	0.02	0.15	0.01	467.00	1.89	0.02	13.00

Statistical Parameters of the Saturated Paste Extract Data for the Other (Polymer, K2CO3, SAPP-Polymer, K-Acetate, Metal-OH, SAPP-K) Solid Phase Samples.

Parameter	Satn	E.C.	pH	NO3	NH4	Alk.	HCO3	CO3	OH	Cl	Al	Cr	Fe	V
	(%)	(dS/m)		(mg/L)										
Count (N)	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
Mean	79.50	7.20	8.37	0.86	0.79	619.38	499.98	118.77	0.58	680.74	1.21	0.01	0.07	0.03
Median	71.50	6.94	8.17	0.38	0.35	282.00	279.50	3.57	0.07	532.50	1.06	0.01	0.01	0.02
StDev (sd)	37.36	2.76	0.75	1.08	1.24	844.86	632.41	270.39	1.23	685.98	0.98	0.00	0.22	0.08
Maximum	252.00	13.40	10.10	4.50	6.64	3920.00	3380.00	1110.00	6.44	2970.00	2.94	0.04	1.01	0.55
Minimum	39.50	2.77	7.10	0.00	0.00	102.00	102.00	0.29	0.01	62.20	0.10	0.01	0.01	0.02

Satn = Percent Saturation; E.C. = Electrical Conductivity (ds/m); Alk = Alkalinity (mg CaCO3/L); HCO3, CO3, OH reported as mg CaCO3/L; SAR = Sodium Adsorption Ratio.

Parameter	Ti	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na	K	Li	Sr	B	Ba	P
	(mg/L)														
Count (N)	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
Mean	0.01	0.01	0.02	0.05	0.16	0.05	281.00	14.20	1511.57	542.87	0.07	2.83	0.61	0.11	0.25
Median	0.01	0.01	0.01	0.05	0.15	0.01	244.50	7.70	1320.00	81.05	0.02	2.20	0.43	0.09	0.15
StDev (sd)	0.01	0.00	0.05	0.00	0.08	0.11	253.88	19.64	648.90	889.23	0.08	2.43	0.64	0.09	0.37
Maximum	0.03	0.01	0.30	0.05	0.36	0.65	731.00	91.10	4310.00	3190.00	0.34	10.40	3.01	0.56	2.20
Minimum	0.01	0.01	0.01	0.05	0.01	0.00	2.96	0.41	680.00	15.80	0.02	0.16	0.04	0.01	0.05

Parameter	Mo	Ni	Se	Co	SO4	Si	As	SAR
	(mg/L)							
Count (N)	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
Mean	1.18	0.02	0.16	0.01	1127.38	4.59	0.14	46.31
Median	0.95	0.02	0.15	0.01	1025.00	3.34	0.08	29.80
StDev (sd)	0.87	0.02	0.03	0.00	536.99	3.62	0.20	40.00
Maximum	3.58	0.11	0.31	0.01	2380.00	17.70	1.05	173.00
Minimum	0.09	0.02	0.15	0.01	191.00	0.70	0.02	10.20

APPENDIX 7: STATISTICAL PARAMETERS FOR EC IN THE SOLID PHASE WASTE TYPES FOR THE DIFFERENT ERCB REGIONS

Statistical Parameters for Saturated Paste EC (dS/m) in the Freshwater Gel Solid Phase Samples for the Different ERCB Regions.

	ERCB Region							
Parameter	3	4	5	6	7	8	9	10
Count (N)	26.00	22.00	20.00	54.00	71.00	46.00	86.00	65.00
Mean	11.08	8.99	8.00	7.29	7.22	10.24	7.99	9.33
Median	7.99	7.55	7.93	6.10	6.46	7.38	7.39	8.49
Std. Dev.	9.03	4.15	2.70	5.11	3.76	15.01	3.89	4.18
Maximum	50.40	21.70	13.30	23.30	33.30	98.20	21.70	26.00
Minimum	4.97	4.51	3.32	1.65	2.94	2.59	2.40	3.39

Statistical Parameters for Saturated Paste EC (dS/m) in the Invert Solid Phase Samples for the Different ERCB Regions.

	ERCB Region				
Parameter	4	6	8	9	10
Count (N)	15.00	18.00	6.00	40.00	7.00
Mean	30.12	25.38	6.68	28.16	13.90
Median	35.00	17.50	5.25	30.90	13.60
Std. Dev.	21.36	13.29	3.31	18.03	3.01
Maximum	76.20	54.10	12.50	63.40	19.00
Minimum	4.49	10.90	3.99	1.61	10.50

Statistical Parameters for Saturated Paste EC (dS/m) in the KCl Solid Phase Samples for the Different ERCB Regions.

	ERCB Region					
Parameter	3	4	6	7	8	9
Count (N)	5.00	39.00	20.00	26.00	10.00	22.00
Mean	24.00	55.53	29.84	33.73	17.38	49.02
Median	25.70	43.10	19.30	34.40	14.55	43.30
Std.Dev.	3.96	47.50	25.21	27.28	10.83	31.36
Maximum	27.40	162.00	75.60	124.00	37.60	145.00
Minimum	17.80	10.50	2.04	3.36	2.63	11.90

Statistical Parameters for Saturated Paste EC (dS/m) in the NaCl Solid Phase Samples for the Different ERCB Regions.

Parameter	- ERCB Region - 7	 9
Count (N)	5.00	6.00
Mean	130.20	61.14
Median	129.00	24.05
Std. Dev.	6.46	72.45
Maximum	141.00	157.00
Minimum	124.00	5.15

Statistical Parameters for Saturated Paste EC (dS/m) in the Other (Polymer, K2CO3, SAPP-Polymer, K-Acetate, Metal-OH, SAPP-K) Solid Phase Samples for the Different ERCB Regions.

	------- ERCB Region --------			
Parameter	3	6	8	9
Count (N)	5.00	10.00	10.00	17.00
Mean	8.46	4.23	7.94	8.15
Median	8.18	4.20	7.62	7.08
Std. Dev.	0.95	0.92	2.56	2.81
Maximum	9.86	6.30	13.00	13.40
Minimum	7.30	2.77	3.34	4.22

APPENDIX 8: STATISTICAL PARAMETERS FOR CL IN THE SOLID PHASE WASTE TYPES FOR THE DIFFERENT ERCB REGIONS

Statistical Parameters for Saturated Paste Cl (mg/L) in the Freshwater Gel Solid Phase Samples for the Different ERCB Regions.

	ERCB Region							
Parameter	3	4	5	6	7	8	9	10
Count (N)	26.0	22.0	20.0	54.0	71.0	46.0	86.0	65.0
Mean	2529.2	1274.2	1284.5	464.1	1261.2	1939.5	563.3	970.0
Median	763.5	191.0	943.0	203.0	442.0	341.0	236.5	505.0
Std. Dev.	5064.4	2238.3	853.3	1042.0	3413.3	7000.8	736.3	1211.4
Maximum	25100.0	8500.0	3330.0	5780.0	24800.0	45400.0	4470.0	6220.0
Minimum	248.0	56.9	138.0	30.3	87.3	64.0	0.0	77.9

Statistical Parameters for Saturated Paste Cl (mg/L) in the Invert Solid Phase Samples for Different ERCB Regions.

	ERCB Region				
Parameter	4	6	8	9	10
Count (N)	15.00	18.00	6.00	40.00	7.00
Mean	13573.27	12987.78	606.17	13083.85	4745.71
Median	16300.00	9600.00	592.00	12900.00	4750.00
Std. Dev.	13422.61	9560.85	179.40	10304.20	1338.04
Maximum	44800.00	29700.00	866.00	35900.00	7000.00
Minimum	230.00	2390.00	392.00	195.00	3250.00

Statistical Parameters for Saturated Paste Cl (mg/L) in the KCl Solid Phase Samples for the Different ERCB Regions.

	ERCB Region					
Parameter	3	4	6	7	8	9
Count (N)	5.00	39.00	20.00	26.00	10.00	22.00
Mean	7580.00	25441.92	11026.87	12223.53	4592.90	21381.36
Median	8230.00	17700.00	6565.00	12350.00	2240.00	17000.00
Std. Dev.	1573.13	26212.66	11618.84	14197.52	5279.87	19441.37
Maximum	8900.00	87500.00	35900.00	65100.00	16000.00	85400.00
Minimum	5060.00	2450.00	12.70	17.00	428.00	1210.00

Statistical Parameters for Saturated Paste Cl (mg/L) in the NaCl Solid Phase Samples for the Different ERCB Regions.

Parameter	ERCB Region 7	ERCB Region 9
Count (N)	5.00	6.00
Mean	187400.00	59527.50
Median	187000.00	12850.00
Std. Dev.	1673.32	82811.63
Maximum	190000.00	180000.00
Minimum	186000.00	158.00

Statistical Parameters for Saturated Paste Cl (mg/L) in the Other (Polymer, K2CO3, SAPP-Polymer, K-Acetate, Metal-OH, SAPP-K) Solid Phase Samples for the Different ERCB Regions.

Parameter	ERCB Region 3	6	8	9
Count (N)	5.00	10.00	10.00	17.00
Mean	712.80	147.99	743.44	947.80
Median	737.00	109.55	569.50	689.00
Std. Dev.	141.14	91.28	684.47	822.61
Maximum	875.00	308.00	1920.00	2970.00
Minimum	558.00	62.20	88.40	90.60

APPENDIX 9: STATISTICAL PARAMETERS FOR SAR IN THE SOLID PHASE WASTE TYPES FOR THE DIFFERENT ERCB REGIONS

Statistical Parameters for Saturated Paste SAR in the Freshwater Gel Solid Phase Samples for the Different ERCB Regions.

	ERCB Region							
Parameter	3	4	5	6	7	8	9	10
Count (N)	26.00	22.00	20.00	54.00	71.00	46.00	86.00	65.00
Mean	42.75	32.80	63.92	72.03	20.70	95.16	32.49	32.34
Median	35.55	26.30	47.40	46.65	19.70	29.80	26.00	22.60
Std. Dev.	29.65	19.56	43.57	66.22	9.55	253.04	19.49	24.66
Maximum	126.00	88.20	169.00	385.00	57.90	1530.00	96.80	122.00
Minimum	14.50	4.55	7.24	18.10	9.01	10.30	2.61	7.25

Statistical Parameters for Saturated Paste SAR Invert Solid Phase Samples for the Different ERCB Regions.

	ERCB Region				
Parameter	4	6	8	9	10
Count (N)	15.00	18.00	6.00	40.00	7.00
Mean	18.08	40.43	67.31	18.54	8.17
Median	12.80	12.85	9.31	12.40	7.46
Std. Dev.	13.25	60.50	140.10	14.17	1.81
Maximum	47.40	217.00	353.00	55.40	10.20
Minimum	0.85	6.68	4.31	3.95	5.61

Statistical Parameters for Saturated Paste SAR in the KCl Solid Phase Samples for the Different ERCB Regions.

	ERCB Region					
Parameter	3	4	6	7	8	9
Count (N)	5.00	39.00	20.00	26.00	10.00	22.00
Mean	12.24	65.43	17.44	46.27	69.87	32.80
Median	12.30	22.80	15.60	32.70	30.20	24.35
Std. Dev.	1.88	88.79	11.56	47.71	84.46	24.05
Maximum	15.10	399.00	48.70	229.00	268.00	121.00
Minimum	10.40	11.20	2.48	2.87	8.29	13.70

Statistical Parameters for Saturated Paste SAR in the NaCl Solid Phase Samples for the Different ERCB Regions.

Parameter	-- ERCB Region -- 7	9
Count (N)	5.00	6.00
Mean	1176.00	497.78
Median	1170.00	44.30
Std. Dev.	122.60	897.84
Maximum	1340.00	2270.00
Minimum	1040.00	13.00

Statistical Parameters for Saturated Paste SAR in the Other (Polymer, K2CO3, SAPP-Polymer, K-Acetate, Metal-OH, SAPP-K) Solid Phase Samples for the Different ERCB Regions.

Parameter	-------- ERCB Region -------- 3	6	8	9
Count (N)	5.00	10.00	10.00	17.00
Mean	25.20	33.51	28.58	70.48
Median	21.70	32.60	22.15	84.90
Std. Dev.	9.03	8.42	15.53	53.34
Maximum	41.00	49.50	56.20	173.00
Minimum	18.40	19.70	14.30	10.20

APPENDIX 10: STATISTICAL PARAMETERS OF THE DTPA-NH4HCO3 EXTRACT DATA FOR THE SOLID PHASE SAMPLES

Statstical Parameters of the DTPA-NH4HCO3 Extract Data for the Freshwater Gel Solid Phase Samples.

Parameter	Fe	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na	K	B
						(ug/g)					
Count (N)	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00
Mean	195.51	0.14	7.24	12.71	52.58	11.87	199.67	121.40	3306.80	494.08	1.39
Median	186.00	0.13	6.50	9.25	13.90	10.80	195.00	101.00	2630.00	318.50	1.00
StDev (sd)	92.96	0.06	3.15	16.32	113.73	6.27	96.16	80.61	2405.06	1574.85	1.51
Maximum	567.00	0.75	18.30	270.00	720.00	36.30	868.80	523.00	18200.00	27500.00	17.30
Minimum	17.50	0.13	1.00	1.75	2.25	0.75	38.50	8.25	210.00	57.50	0.13

Parameter	P	Mo	Ni	Se
		(ug/g)		
Count (N)	390.00	390.00	390.00	390.00
Mean	14.49	0.79	2.18	0.58
Median	2.00	0.75	2.00	0.38
StDev (sd)	37.72	0.58	1.14	0.55
Maximum	354.00	3.50	7.50	6.50
Minimum	0.13	0.13	1.00	0.38

Statstical Parameters of the DTPA-NH4HCO3 Extract Data for the Invert Solid Phase Samples.

Parameter	Fe	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na	K	B
						(ug/g)					
Count (N)	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00
Mean	129.76	0.15	5.83	21.43	109.82	7.93	187.52	110.77	1847.80	350.49	2.59
Median	106.00	0.13	4.50	14.65	32.00	6.00	186.50	101.75	1630.00	349.00	1.50
StDev (sd)	89.80	0.08	5.01	23.55	180.19	7.29	84.40	61.31	1062.53	176.63	2.96
Maximum	394.00	0.50	30.80	171.00	735.00	52.00	349.00	290.00	5060.00	812.00	17.30
Minimum	0.13	0.13	0.25	1.50	3.75	0.13	38.30	18.30	11.80	44.30	0.13

Parameter	P	Mo	Ni	Se
		(ug/g)		
Count (N)	86.00	86.00	86.00	86.00
Mean	5.94	0.39	1.22	0.46
Median	3.13	0.25	0.75	0.38
StDev (sd)	8.00	0.25	1.32	0.20
Maximum	40.50	1.00	8.50	1.25
Minimum	0.13	0.13	0.13	0.38

Statstical Parameters of the DTPA-NH4HCO3 Extract Data for the KCl Solid Phase Samples.

Parameter	Fe	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na	K	B
	(ug/g)										
Count (N)	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00
Mean	166.45	0.13	7.66	15.08	58.03	13.53	206.37	140.33	3753.62	12343.75	1.33
Median	153.50	0.13	7.75	12.15	18.90	13.00	196.50	92.05	1895.00	8060.00	0.50
StDev (sd)	91.35	0.02	2.78	9.96	110.86	6.69	94.95	159.89	5487.54	13879.89	2.44
Maximum	615.00	0.25	16.00	56.50	895.00	31.00	788.00	915.00	46500.00	75200.00	16.80
Minimum	0.50	0.13	1.00	0.50	3.50	0.13	42.00	7.25	196.00	127.00	0.13

Parameter	P	Mo	Ni	Se
	(ug/g)			
Count (N)	122.00	122.00	122.00	122.00
Mean	5.41	0.47	2.10	0.52
Median	2.00	0.50	1.88	0.38
StDev (sd)	12.02	0.36	1.10	0.52
Maximum	105.00	2.00	6.00	3.00
Minimum	0.13	0.13	0.50	0.38

Statstical Parameters of the DTPA-NH4HCO3 Extract Data for the NaCl Solid Phase Samples.

Parameter	Fe	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na	K	B
						(ug/g)					
Count (N)	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00
Mean	117.53	0.13	4.41	19.05	12.51	5.19	181.68	63.18	101797.27	3504.86	1.70
Median	114.00	0.13	4.00	13.50	7.50	2.75	176.00	46.00	168000.00	413.00	1.50
StDev (sd)	52.60	0.00	1.82	13.12	11.78	4.74	63.34	40.66	88528.98	3782.04	0.81
Maximum	211.00	0.13	7.00	47.30	42.80	17.00	260.00	167.00	206000.00	7720.00	3.50
Minimum	46.30	0.13	1.50	5.50	2.75	1.50	83.50	25.00	1560.00	48.50	0.50

Parameter	P	Mo	Ni	Se
		(ug/g)		
Count (N)	11.00	11.00	11.00	11.00
Mean	1.55	0.19	0.84	0.38
Median	1.50	0.13	0.13	0.38
StDev (sd)	0.47	0.15	0.93	0.00
Maximum	2.25	0.50	2.75	0.38
Minimum	1.00	0.13	0.13	0.38

Statstical Parameters of the DTPA-NH4HCO3 Extract Data for the Other (Polymer, K2CO3, SAPP-Polymer, K-Acetate, Metal-OH, SAPP-K) Solid Phase Samples.

Parameter	Fe	Cd	Cu	Pb	Zn	Mn	Ca	Mg	Na	K	B
	(ug/g)										
Count (N)	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
Mean	202.19	0.13	8.13	11.10	27.04	14.15	207.20	107.26	2397.71	1672.67	1.37
Median	209.00	0.13	7.63	10.00	13.15	12.05	208.50	86.80	1855.00	375.50	0.50
StDev (sd)	75.91	0.00	3.54	5.69	28.00	7.14	62.41	79.24	1763.67	2162.97	2.06
Maximum	350.00	0.13	25.50	24.50	102.00	32.80	320.00	431.00	10700.00	6650.00	10.50
Minimum	56.50	0.13	3.75	2.50	4.50	5.25	91.80	29.10	739.00	216.00	0.13

Parameter	P	Mo	Ni	Se
	(ug/g)			
Count (N)	42.00	42.00	42.00	42.00
Mean	15.70	0.94	2.51	0.39
Median	1.63	0.88	2.50	0.38
StDev (sd)	29.65	0.65	0.95	0.10
Maximum	117.00	2.75	5.25	1.00
Minimum	0.50	0.13	1.00	0.38

APPENDIX 11: STATISTICAL PARAMETERS OF THE TOTAL ELEMENTAL ANALYSIS DATA FOR THE SOLID PHASE SAMPLES

Statstical Parameters of the Total Elemental Analysis Data for the Freshwater Gel Solid Phase Samples.

Parameter	Mn	Na	K	Ca	Mg	Cu	Zn	P	Mo	Al	Fe
						(ug/g)					
Count (N)	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00
Mean	348.57	7126.74	13956.31	7554.52	5170.91	40.30	281.59	770.39	26.37	41282.55	27077.97
Median	334.50	7230.00	14400.00	6310.00	4505.00	36.90	125.50	671.00	26.95	45500.00	28900.00
StDev (sd)	113.99	2666.71	4220.34	6308.38	2625.77	16.56	604.43	1108.71	16.71	20826.99	7934.39
Maximum	821.00	22200.00	50300.00	108000.00	20600.00	128.00	5530.00	21400.00	273.00	79400.00	49600.00
Minimum	45.80	429.00	1120.00	6.00	98.60	3.39	10.90	42.10	8.50	30.00	1170.00

Parameter	Ti	V	Cr	Ba	Ni	Sr	Li	Zr	Cd	Pb
					(ug/g)					
Count (N)	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00	390.00
Mean	2992.93	126.53	94.49	288.15	44.76	156.05	26.97	88.88	0.61	75.10
Median	3105.00	121.00	88.15	84.90	44.55	116.50	26.65	93.90	0.52	50.22
StDev (sd)	916.14	50.62	44.45	1420.42	14.30	228.64	14.99	29.54	0.63	141.47
Maximum	11200.00	433.00	433.00	19900.00	91.60	3010.00	64.20	157.00	4.29	2665.29
Minimum	214.00	4.50	11.40	5.73	4.50	7.92	7.00	4.50	0.06	1.00

Statistical Parameters of the Total Elemental Analysis Data for the Invert Solid Phase Samples.

Parameter	Mn	Na	K	Ca	Mg	Cu	Zn	P	Mo	Al	Fe	Ti
						(ug/g)						
Count (N)	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00
Mean	282.88	5449.16	9571.74	6887.79	6577.42	46.31	476.02	521.57	17.76	22944.56	18455.81	1961.93
Median	275.50	5060.00	9790.00	6465.00	4710.00	37.90	173.50	541.00	17.95	23400.00	19300.00	1945.00
StDev (sd)	99.87	2380.38	3959.67	3546.99	5116.34	26.67	876.74	208.88	9.64	18067.96	8324.60	849.70
Maximum	543.00	12400.00	19300.00	18300.00	30700.00	121.00	5120.00	1310.00	40.60	60300.00	34100.00	3830.00
Minimum	96.00	55.50	1130.00	46.00	588.00	7.45	53.30	120.00	8.50	94.90	1830.00	185.00

Parameter	V	Cr	Ba	Ni	Sr	Li	Zr	Cd	Pb
					(ug/g)				
Count (N)	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00
Mean	80.47	60.51	866.28	36.84	288.16	18.95	56.06	0.59	83.50
Median	84.75	68.25	74.15	36.65	129.00	17.25	66.60	0.53	59.34
StDev (sd)	42.36	23.04	3022.62	15.30	554.47	13.14	35.08	0.51	89.25
Maximum	243.00	110.00	23400.00	78.00	3110.00	59.70	129.00	2.63	692.04
Minimum	4.50	10.60	27.50	4.50	11.10	7.00	4.50	0.06	5.97

Statistical Parameters of the Total Elemental Analysis Data for the KCl Solid Phase Samples.

Parameter	Mn	Na	K	Ca	Mg	Cu	Zn	P	Mo	Al	Fe	Ti
	(ug/g)											
Count (N)	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00
Mean	358.30	8812.21	32274.84	6896.52	5236.64	37.14	222.81	582.55	22.79	43999.82	27085.57	2949.20
Median	365.50	8225.00	25950.00	6165.00	3910.00	34.20	136.50	592.50	24.50	51450.00	28200.00	3065.00
StDev (sd)	107.96	5051.02	24837.61	2839.77	4782.66	12.94	298.64	135.34	11.11	20952.30	6987.54	702.12
Maximum	743.00	50600.00	143000.00	15100.00	35600.00	97.50	2290.00	884.00	52.40	74100.00	39600.00	4330.00
Minimum	139.00	1340.00	3100.00	285.00	1310.00	4.12	64.80	215.00	8.50	87.60	3680.00	717.00

Parameter	V	Cr	Ba	Ni	Sr	Li	Zr	Cd	Pb
	(ug/g)								
Count (N)	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00	122.00
Mean	112.46	90.29	141.17	43.15	119.39	23.78	84.23	0.50	81.16
Median	108.00	83.70	87.00	40.10	111.00	22.20	87.85	0.30	63.71
StDev (sd)	35.01	47.71	330.76	27.65	66.67	14.37	27.72	0.67	61.92
Maximum	215.00	347.00	3200.00	312.00	646.00	60.10	154.00	6.12	312.69
Minimum	25.40	24.60	12.40	12.30	9.36	7.00	4.50	0.06	1.00

Statistical Parameters of the Total Elemental Analysis Data for the NaCl Solid Phase Samples.

Parameter	Mn	Na	K	Ca	Mg	Cu	Zn	P	Mo	Al	Fe	Ti
						(ug/g)						
Count (N)	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00
Mean	220.39	82386.36	14760.91	12481.82	5916.36	21.37	92.58	331.64	11.94	15390.00	13001.82	1627.73
Median	174.00	101000.00	18000.00	12700.00	3540.00	24.40	105.00	273.00	8.50	4760.00	11200.00	1280.00
StDev (sd)	120.12	75765.10	7908.46	5810.79	5939.26	12.03	48.30	171.62	7.67	23538.62	9509.67	1008.87
Maximum	474.00	234000.00	22700.00	23700.00	17800.00	37.90	185.00	673.00	28.80	63700.00	31000.00	3600.00
Minimum	99.30	250.00	2670.00	3520.00	1640.00	1.50	32.20	154.00	8.50	3360.00	2290.00	663.00

Parameter	V	Cr	Ba	Ni	Sr	Li	Zr	Cd	Pb
					(ug/g)				
Count (N)	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00
Mean	64.38	162.66	172.20	24.51	139.55	23.90	36.06	0.23	84.59
Median	55.40	82.40	186.00	24.90	122.00	7.00	36.50	0.28	82.65
StDev (sd)	39.04	123.98	159.68	8.59	63.69	19.59	33.00	0.15	48.74
Maximum	144.00	316.00	421.00	39.70	305.00	49.20	100.00	0.55	182.16
Minimum	16.00	33.10	6.15	4.50	73.10	7.00	4.50	0.06	10.35

Statistical Parameters of the Total Elemental Analysis Data for the Other (Polymer, K2CO3, SAPP-Polymer, K-Acetate, Metal-OH, SAPP-K) Solid Phase Samples.

Parameter	Mn	Na	K	Ca	Mg	Cu	Zn	P	Mo	Al	Fe	Ti
	(ug/g)											
Count (N)	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
Mean	380.64	7989.05	18373.81	6063.69	4124.40	39.00	152.40	767.02	31.82	57614.29	32420.24	3511.67
Median	399.25	7400.00	18000.00	5940.00	4010.00	34.45	142.50	697.50	31.63	57800.00	32575.00	3475.00
StDev (sd)	105.58	2497.32	3745.16	2316.11	1142.89	12.41	46.43	195.48	7.53	9542.15	3727.62	440.77
Maximum	569.00	18200.00	25300.00	13100.00	6630.00	68.40	278.00	1330.00	49.30	79800.00	43000.00	4600.00
Minimum	185.00	4100.00	12200.00	2600.00	2470.00	23.70	92.40	462.00	17.30	36500.00	24300.00	2670.00

Parameter	V	Cr	Ba	Ni	Sr	Li	Zr	Cd	Pb
	(ug/g)								
Count (N)	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
Mean	154.72	94.00	87.09	50.30	114.49	23.38	100.12	0.46	59.95
Median	147.50	94.30	78.98	50.25	116.50	25.93	100.45	0.30	41.99
StDev (sd)	53.53	15.80	34.74	10.64	26.33	26.89	15.94	0.29	41.83
Maximum	309.00	127.00	201.00	72.30	168.00	71.80	135.00	1.15	172.59
Minimum	77.00	59.80	43.30	32.60	62.90	-13.20	72.70	0.06	17.81

APPENDIX 12: STATISTICAL PARAMETERS FOR TOTAL ELEMENTAL CU IN THE SOLID PHASE WASTE TYPES FOR THE DIFFERENT ERCB REGIONS

Statistical Parameters for Total Elemental Cu (µg/g) in the Freshwater Gel Solid Phase Samples for the Different ERCB Regions.

	ERCB Region							
Parameter	3	4	5	6	7	8	9	10
Count (N)	26.00	22.00	20.00	54.00	71.00	46.00	86.00	65.00
Mean	48.07	35.52	42.19	44.29	30.97	41.91	42.00	41.74
Median	37.35	36.80	38.90	41.50	30.40	40.85	35.50	42.20
Std. Dev.	28.32	12.36	11.49	18.61	8.99	15.82	18.74	9.82
Maximum	128.00	56.00	66.20	82.80	61.20	71.50	110.00	69.20
Minimum	14.00	10.60	26.60	8.19	7.45	12.80	3.39	17.50

Statistical Parameters for Total Elemental Cu (µg/g) in the Invert Solid Phase Samples for the Different ERCB Regions.

	ERCB Region				
Parameter	4	6	8	9	10
Count (N)	15.00	18.00	6.00	40.00	7.00
Mean	46.62	58.23	18.43	46.96	35.17
Median	45.80	43.25	15.70	37.90	36.10
Std. Dev.	19.56	34.36	8.33	26.01	5.26
Maximum	81.20	121.00	31.10	114.00	41.00
Minimum	7.45	21.50	8.50	18.70	25.50

Statistical Parameters for Total Elemental Cu (µg/g) in the KCl Solid Phase Samples for the Different ERCB Regions.

	ERCB Region					
Parameter	3	4	6	7	8	9
Count (N)	5.00	39.00	20.00	26.00	10.00	22.00
Mean	27.34	40.53	29.26	33.17	32.27	47.41
Median	29.50	38.40	29.85	32.65	32.05	42.65
Std. Dev.	7.90	13.79	10.49	5.32	4.65	14.87
Maximum	33.10	97.50	47.10	45.30	40.40	80.30
Minimum	13.90	23.30	4.12	25.10	25.60	28.20

Statistical Parameters for Total Elemental Cu (μg/g) in the NaCl Solid Phase Samples for the Different ERCB Regions.

Parameter	- ERCB Region - 7	 9
Count (N)	5.00	6.00
Mean	30.30	13.92
Median	30.80	12.86
Std. Dev.	5.27	11.00
Maximum	37.90	27.70
Minimum	23.70	1.50

Statistical Parameters for Total Elemental Cu (μg/g) in the Other (Polymer, K_2CO_3, SAPP-Polymer, K-Acetate Metal-OH, SAPP-K) Solid Phase Samples for the Different ERCB Regions.

	-------- ERCB Region --------			
Parameter	3	6	8	9
Count (N)	5.00	10.00	10.00	17.00
Mean	35.00	28.36	30.57	51.39
Median	34.60	28.10	30.30	47.30
Std. Dev.	3.31	3.09	2.93	9.92
Maximum	39.90	33.00	34.75	68.40
Minimum	30.60	23.70	25.90	32.50

APPENDIX 13: STATISTICAL PARAMETERS FOR TOTAL ELEMENTAL CR IN THE SOLID PHASE WASTE TYPES FOR THE DIFFERENT ERCB REGIONS

Statistical Parameters for Total Elemental Cr (μg/g) in the Freshwater Gel Solid Phase Samples for the Different ERCB Regions.

	ERCB Region							
Parameter	3	4	5	6	7	8	9	10
Count (N)	26.00	22.00	20.00	54.00	71.00	46.00	86.00	65.00
Mean	70.19	64.98	168.02	96.46	80.00	108.56	92.66	98.26
Median	75.00	72.75	144.50	97.30	78.90	87.25	87.65	99.00
Std. Dev.	22.68	24.57	71.02	39.11	21.11	76.43	26.13	26.75
Maximum	101.00	97.00	356.00	211.00	154.00	433.00	176.00	172.00
Minimum	15.40	11.40	81.40	11.70	40.80	57.30	31.70	38.60

Statistical Parameters for Total Elemental Cr (μg/g) in the Invert Solid Phase Samples for the Different ERCB Regions.

	ERCB Region				
Parameter	4	6	8	9	10
Count (N)	15.00	18.00	6.00	40.00	7.00
Mean	55.50	45.78	52.82	68.24	71.53
Median	58.30	39.10	47.90	72.05	71.40
Std. Dev.	23.69	28.09	20.49	18.81	3.46
Maximum	90.90	110.00	92.80	104.00	77.00
Minimum	12.70	10.60	36.30	12.90	66.90

Statistical Parameters for Total Elemental Cr (μg/g) in the KCl Solid Phase Samples for the Different ERCB Regions.

	ERCB Region					
Parameter	3	4	6	7	8	9
Count (N)	5.00	39.00	20.00	26.00	10.00	22.00
Mean	82.62	115.31	72.42	73.90	79.60	88.15
Median	88.50	86.00	78.15	73.40	81.80	89.65
Std. Dev.	15.69	73.24	25.36	23.11	17.91	11.48
Maximum	98.60	347.00	107.00	135.00	110.00	106.00
Minimum	60.70	67.20	24.60	31.40	47.10	61.90

Statistical Parameters for Total Elemental Cr (µg/g) in the NaCl Solid Phase Samples for the Different ERCB Regions.

	- ERCB Region -	
Parameter	7	9
Count (N)	5.00	6.00
Mean	290.40	56.22
Median	284.00	51.90
Std. Dev.	21.66	21.31
Maximum	316.00	82.40
Minimum	261.00	33.10

Statistical Parameters for Total Elemental Cr (µg/g) in the Other (Polymer, K_2CO_3, SAPP-Polymer, K-Acetate Metal-OH, SAPP-K) Solid Phase Samples for the Different ERCB Regions.

	--------- ERCB Region -------			
Parameter	3	6	8	9
Count (N)	5.00	10.00	10.00	17.00
Mean	90.66	84.12	98.46	98.19
Median	94.30	79.00	94.80	103.00
Std. Dev.	7.90	12.12	22.03	13.16
Maximum	98.80	107.00	127.00	114.00
Minimum	79.50	73.70	69.10	59.80

APPENDIX 14: STATISTICAL PARAMETERS FOR TOTAL ELEMENTAL NI IN THE SOLID PHASE WASTE TYPES FOR THE DIFFERENT ERCB REGIONS

Statistical Parameters for Total Elemental Ni (µg/g) in the Freshwater Gel Solid Phase Samples for the Different ERCB Regions.

	ERCB Region							
Parameter	3	4	5	6	7	8	9	10
Count (N)	26.00	22.00	20.00	54.00	71.00	46.00	86.00	65.00
Mean	38.40	37.79	51.29	44.86	42.02	45.85	41.98	53.51
Median	38.85	38.80	49.90	44.95	42.70	44.00	41.15	54.80
Std. Dev.	20.71	10.40	14.76	19.79	10.56	11.46	12.23	9.74
Maximum	78.30	53.80	80.80	91.60	64.90	73.20	73.60	71.60
Minimum	4.50	14.70	20.30	4.50	15.20	27.30	4.50	29.20

Statistical Parameters for Total Elemental Ni (µg/g) in the Invert Solid Phase Samples for the Different ERCB Regions.

	ERCB Region				
Parameter	4	6	8	9	10
Count (N)	15.00	18.00	6.00	40.00	7.00
Mean	32.66	27.26	27.53	43.55	40.09
Median	36.30	25.00	24.85	39.50	40.70
Std. Dev.	13.43	13.23	11.83	15.38	5.09
Maximum	60.50	57.90	51.00	78.00	45.10
Minimum	4.50	10.70	18.00	15.30	30.40

Statistical Parameters for Total Elemental Ni (µg/g) in the KCl Solid Phase Samples for the Different ERCB Regions.

	ERCB Region					
Parameter	3	4	6	7	8	9
Count (N)	5.00	39.00	20.00	26.00	10.00	22.00
Mean	32.40	37.24	37.54	49.74	42.63	53.62
Median	37.30	35.20	37.55	40.40	43.90	48.25
Std. Dev.	9.56	11.09	11.82	54.06	6.63	15.81
Maximum	41.80	68.70	55.00	312.00	52.00	84.80
Minimum	18.30	19.30	12.30	25.50	32.80	29.10

Statistical Parameters for Total Elemental Ni (μg/g) in the NaCl Solid Phase Samples for the Different ERCB Regions.

Parameter	- ERCB Region - 7	 9
Count (N)	5.00	6.00
Mean	24.22	24.75
Median	24.90	24.40
Std. Dev.	2.13	11.99
Maximum	26.40	39.70
Minimum	20.70	4.50

Statistical Parameters for Total Elemental Ni (μg/g) in the Other (Polymer, K_2CO_3, SAPP-Polymer, K-Acetate, Metal-OH, SAPP-K) Solid Phase Samples for the Different ERCB Regions.

	--------- ERCB Region --------			
Parameter	3	6	8	9
Count (N)	5.00	10.00	10.00	17.00
Mean	45.14	38.46	49.17	59.44
Median	46.30	38.30	50.80	59.20
Std. Dev.	2.83	3.30	6.49	8.51
Maximum	47.80	43.40	55.90	72.30
Minimum	41.90	32.60	37.20	39.00

APPENDIX 15: STATISTICAL PARAMETERS FOR TOTAL ELEMENTAL ZN IN THE SOLID PHASE WASTE TYPES FOR THE DIFFERENT ERCB REGIONS

Statistical Parameters for Total Elemental Zn (µg/g) in the Freshwater Gel Solid Phase Samples for the Different ERCB Regions.

	ERCB Region							
Parameter	3	4	5	6	7	8	9	10
Count (N)	26.00	22.00	20.00	54.00	71.00	46.00	86.00	65.00
Mean	248.51	580.85	143.37	314.55	121.54	121.13	564.93	122.18
Median	163.00	118.50	124.50	116.50	114.00	117.00	164.50	123.00
Std. Dev.	312.75	937.35	53.20	622.80	43.57	20.25	1008.14	32.46
Maximum	1500.00	3080.00	310.00	4080.00	248.00	182.00	5530.00	235.00
Minimum	10.90	48.40	94.00	71.50	56.60	88.60	62.20	56.90

Statistical Parameters for Total Elemental Zn (µg/g) in the Invert Solid Phase Samples for the Different ERCB Regions.

	ERCB Region				
Parameter	4	6	8	9	10
Count (N)	15.00	18.00	6.00	40.00	7.00
Mean	882.93	1039.72	129.30	182.35	129.86
Median	301.00	422.00	107.40	163.50	125.00
Std. Dev.	1457.20	1141.91	66.05	72.26	22.15
Maximum	5120.00	4210.00	252.00	395.00	167.00
Minimum	116.00	106.00	71.30	53.30	103.00

Statistical Parameters for Total Elemental Zn (µg/g) in the KCl Solid Phase Samples for the Different ERCB Regions.

	ERCB Region					
Parameter	3	4	6	7	8	9
Count (N)	5.00	39.00	20.00	26.00	10.00	22.00
Mean	115.60	182.86	545.35	151.69	215.60	112.10
Median	119.00	162.00	236.00	127.50	195.50	112.00
Std. Dev.	14.48	70.73	639.07	70.81	103.01	29.04
Maximum	131.00	369.00	2290.00	339.00	383.00	192.00
Minimum	99.00	84.30	100.00	80.70	108.00	64.80

Statistical Parameters for Total Elemental Zn (µg/g) in the NaCl Solid Phase Samples for the Different ERCB Regions.

Parameter	- ERCB Region - 7	 9
Count (N)	5.00	6.00
Mean	129.12	62.13
Median	118.00	47.10
Std. Dev.	34.85	35.30
Maximum	185.00	106.00
Minimum	98.60	32.20

Statistical Parameters for Total Elemental Zn (µg/g) in the Other (Polymer, K_2CO_3, SAPP-Polymer, K-Acetate Metal-OH, SAPP-K) Solid Phase Samples for the Different ERCB Regions.

Parameter	--------- ERCB Region -------- 3	 6	 8	 9
Count (N)	5.00	10.00	10.00	17.00
Mean	248.60	113.59	130.65	159.74
Median	249.00	113.00	129.50	155.00
Std. Dev.	26.08	10.24	17.89	30.49
Maximum	278.00	131.00	156.00	227.00
Minimum	214.00	92.40	101.00	109.00

APPENDIX 16: MEAN VALUES FOR SELECTED PROPERTIES OF THE DRILLING WASTE SOLID SAMPLES

Mean Values for Selected Properties of the Drilling Waste Solid Samples.

Sump Number	Solid Vol,m3	H2O (%)	E.C. (dS/m)	SAR postcalc	Cl	Na	NO3&NH4-N	B	Oil	Cu	Zn	V
								(mg/Kg)				
SC3	N/A	122.68	5.73	15.59	34.61	783.37	1.57	0.15	500.00	23.48	981.40	80.98
SC4	N/A	24.66	12.25	16.37	1501.47	533.54	0.24	0.04	1500.00	20.42	458.20	57.84
SC5	N/A	15.12	20.90	62.45	820.94	878.32	0.02	0.07	1800.00	11.21	471.20	13.50
SC6	N/A	18.64	42.08	8.94	10866.20	1633.56	9.18	0.22	79000.00	34.26	191.00	112.14
SC7	N/A	316.60	2.37	23.31	618.72	816.25	0.14	0.12	3700.00	32.00	83.78	93.04
SC8	N/A	23.60	5.28	41.15	30.06	829.64	0.22	0.15	1300.00	43.74	130.80	143.92
SC9A	430.0	496.20	13.90	20.11	5060.07	3506.63	1.04	0.36	82400.00	43.10	2182.00	95.54
SC9BD	166.0	290.50	28.60	22.99	9179.03	3405.13	0.96	0.06	74200.00	44.20	4230.00	38.35
SC9C	189.0	39.63	45.35	10.31	10225.81	1712.52	3.70	0.16	86300.00	41.30	163.00	112.93
SC10	612.0	99.40	8.12	33.88	73.08	1543.94	0.68	0.16	1700.00	43.33	107.05	120.17
SC11	157.0	194.14	5.80	30.95	387.06	1602.82	6.13	1.24	1800.00	56.34	118.60	172.60
SC12	53.5	89.04	43.44	12.88	10596.84	1171.52	1.51	0.56	500.00	44.80	94.50	103.08
SC13	110.0	207.16	37.60	374.46	9205.46	5703.62	58.22	0.61	900.00	62.30	118.60	286.60
SC14A	46.0	38.70	4.53	20.10	395.11	702.17	1.13	0.20	800.00	14.35	162.50	104.45
SC14B	100.0	59.10	3.22	16.01	184.07	662.12	0.56	0.09	1500.00	19.78	117.40	107.15
SC15	183.0	97.54	6.39	24.25	85.52	1191.04	0.93	0.31	600.00	27.10	100.10	115.36
SC16	135.0	117.08	6.65	41.72	195.86	2266.48	0.78	1.48	1500.00	39.00	138.60	162.00
SC17	120.0	131.84	7.63	26.53	467.32	1855.76	0.71	1.28	1800.00	47.90	140.40	153.80
SC18	205.0	183.48	7.64	23.09	1716.19	1689.39	1.23	0.26	2000.00	25.20	118.20	121.80
SC19B	880.0	44.55	18.16	19.60	3680.67	1487.87	0.38	0.01	10400.00	41.54	129.00	104.74
SC19C	402.0	35.67	11.72	14.85	1704.27	763.62	0.17	0.03	11500.00	53.72	170.17	96.90
SC21	590.0	105.96	8.46	23.45	1013.34	1664.29	1.69	1.59	2300.00	30.02	124.20	160.60
SC22	N/A	179.08	7.50	30.44	2033.19	3031.90	9.38	3.56	9400.00	32.36	110.08	138.20
SC23	N/A	159.90	7.63	84.44	1471.52	3174.51	0.14	4.44	9300.00	38.04	114.60	177.60
SC24	1148.2	167.80	6.74	20.16	181.97	1285.41	1.26	0.32	1500.00	34.68	162.20	139.74
SC25	373.0	127.02	7.79	35.51	454.85	1947.61	1.68	0.71	1000.00	26.94	103.04	116.14
SC26	672.0	125.98	6.21	12.97	386.73	885.07	42.34	0.57	1300.00	31.64	112.12	141.60
SC27	288.0	102.43	6.06	12.69	149.69	726.91	371.31	0.53	1500.00	30.21	100.40	122.47
SC28	571.0	130.32	11.44	24.45	6735.95	2260.34	1.65	1.25	1500.00	19.41	95.56	101.00
SC29	600.0	158.37	63.78	95.95	22390.41	18584.73	1.34	0.50	2900.00	32.38	89.67	76.72
SC30A	2.4	118.28	5.47	9.18	337.74	664.19	1.31	0.64	2300.00	33.26	167.40	110.86
SC32	561.0	96.36	5.81	12.60	418.28	804.09	0.65	0.77	2900.00	25.83	87.47	92.73
SC33	225.0	308.58	7.33	28.64	413.34	2231.72	0.24	1.33	800.00	25.06	224.40	149.92
SC34	1750.0	272.83	5.58	42.17	221.86	1851.05	0.69	0.60	800.00	36.80	112.83	113.77
SC35	3643.0	164.25	7.96	36.78	254.59	2219.33	0.52	0.30	800.00	37.65	113.51	102.58
SC36	501.0	106.30	52.38	16.79	13442.30	1565.34	1.57	0.05	1000.00	37.16	125.00	144.20
SC37	383.0	122.94	3.90	35.77	141.87	825.43	0.27	0.33	700.00	30.26	117.60	140.92
SC38	278.0	42.72	4.57	26.49	87.73	635.56	0.55	0.20	500.00	26.46	109.68	108.80
SC39	639.0	196.78	7.19	18.18	669.76	1340.11	1.34	0.23	500.00	32.61	114.29	149.25
SC40	1639.0	226.67	13.44	54.62	1703.23	5252.23	1.31	0.58	3200.00	32.84	478.20	117.63
SC41	681.0	482.20	14.70	52.13	2489.45	5041.98	1.09	0.45	38800.00	33.62	269.80	66.60
SC42	133.0	74.36	8.36	19.58	261.46	982.75	1.19	0.33	700.00	43.34	138.40	142.60
SC43	382.0	96.56	8.56	26.71	530.87	1756.61	0.39	0.96	1300.00	36.12	81.48	121.18
SC44	146.0	89.26	6.39	10.47	772.71	716.40	0.95	0.89	1000.00	36.10	73.94	115.40
SC45	768.0	115.01	9.56	20.61	1221.68	1484.76	1.10	0.41	300.00	30.10	121.43	126.51
SC46	781.0	227.65	13.50	21.95	3041.23	2183.09	1.99	0.24	1500.00	42.04	141.88	162.75

E.C. = Electrical conductivity (dS/m); SAR = Sodium Adsorption Ratio (calculated after means taken);
N/A = Data Not Available.

(Continued). Mean Values for Selected Properties of the Drilling Waste Solid Samples.

Sump	Cr	Ni	Cd	Pb
Number	---------	(mg/kg)	---------	
SC3	76.26	35.60	0.38	61.74
SC4	51.64	30.56	0.12	98.28
SC5	14.22	8.02	0.28	46.04
SC6	61.88	35.74	0.70	55.18
SC7	86.66	48.50	0.51	48.21
SC8	100.00	49.98	1.22	54.18
SC9A	69.00	33.78	0.33	208.65
SC9BD	39.15	25.85	0.64	115.54
SC9C	71.50	31.53	0.29	97.28
SC10	84.78	44.05	0.63	145.78
SC11	97.80	64.84	0.73	143.75
SC12	78.82	50.78	0.45	32.21
SC13	286.60	56.36	0.29	80.09
SC14A	76.95	29.05	0.46	46.62
SC14B	71.28	35.68	0.70	24.53
SC15	65.40	37.12	0.65	51.06
SC16	94.30	44.26	0.23	60.55
SC17	91.24	52.34	0.63	61.29
SC18	88.34	33.48	1.59	119.12
SC19B	84.08	41.98	0.40	78.50
SC19C	81.30	43.60	0.52	72.70
SC21	84.82	45.64	0.55	66.74
SC22	173.20	43.54	0.37	43.28
SC23	173.40	47.06	1.25	84.00
SC24	97.22	50.44	0.48	96.22
SC25	78.36	43.96	0.22	44.44
SC26	87.60	44.78	0.36	43.88
SC27	75.50	40.06	0.53	39.65
SC28	69.68	28.42	0.06	90.24
SC29	67.02	32.87	0.45	66.51
SC30A	71.08	41.52	0.45	91.04
SC32	58.31	35.39	0.17	15.60
SC33	122.80	34.62	2.18	38.80
SC34	95.38	35.17	0.24	60.03
SC35	118.84	30.42	0.86	80.19
SC36	98.48	46.18	0.40	37.38
SC37	92.18	40.06	1.20	61.28
SC38	76.06	36.86	1.45	59.68
SC39	99.83	42.88	0.49	26.19
SC40	138.77	40.23	0.26	36.25
SC41	45.80	37.66	0.06	125.16
SC42	73.20	58.48	0.88	58.28
SC43	77.76	52.64	0.15	33.51
SC44	54.06	47.24	0.06	22.18
SC45	133.33	45.41	0.62	50.27
SC46	106.81	61.69	0.81	41.63

(Continued). Mean Values for Selected Properties of the Drilling Waste Solid Samples.

Sump Number	Solid Vol,m3	H2O (%)	E.C. (dS/m)	SAR postcalc	Cl	Na	NO3&NH4-N	B	Oil	Cu	Zn	V
								(mg/Kg)				
SC47	553.0	115.88	10.06	31.15	534.29	2589.09	6.06	0.41	1100.00	42.82	152.60	173.40
SC48	551.0	198.67	4.69	12.26	313.73	726.06	1.13	0.11	4200.00	45.63	130.57	131.00
SC49	1107.0	96.10	9.81	40.12	531.09	2257.40	0.85	0.50	1700.00	35.40	71.30	71.34
SC50	828.0	172.09	7.08	19.33	335.07	1376.08	0.99	0.32	1200.00	50.63	119.25	153.13
SC51	N/A	92.10	8.54	25.19	80.62	1531.81	859.75	0.42	700.00	32.12	128.80	194.20
SC52A	N/A	58.75	89.03	465.74	45626.75	29676.08	1.48	0.20	3700.00	7.86	40.20	38.35
SC52C	N/A	123.45	5.37	13.99	183.17	882.23	2.32	0.36	300.00	26.05	106.00	139.00
SC53	230.0	104.68	24.00	11.99	5329.37	910.93	0.64	0.25	1800.00	27.34	115.60	158.00
SC54	477.0	74.62	6.03	20.77	108.25	1202.43	1.46	0.61	1500.00	36.70	121.00	177.83
SC55	577.0	73.10	6.32	22.84	83.15	1330.75	1.69	0.22	1200.00	26.18	176.40	116.14
SC56A	88.0	347.00	154.50	290.99	69593.75	15922.25	1.54	0.07	8500.00	35.30	289.00	104.90
SC56B	315.0	166.48	102.44	110.99	35981.70	6075.62	1.45	0.01	4300.00	31.28	195.60	128.80
SC56C	17.0	242.00	95.80	54.88	42588.00	9373.00	3.71	0.02	18100.00	30.00	220.00	126.00
SC57	423.0	34.14	42.82	9.81	12283.60	2263.44	4.92	0.10	78700.00	62.30	186.00	83.32
SC58	401.0	132.62	38.76	26.10	9478.70	1980.37	1.00	0.08	3300.00	27.20	187.60	123.46
SC59	346.0	110.32	28.26	20.44	6534.29	1313.97	1.45	0.02	500.00	37.44	108.56	137.00
SC60	320.0	89.00	10.44	83.27	1121.93	632.57	1.39	0.06	1500.00	44.03	189.33	130.00
SC61	755.0	26.98	23.63	11.54	5041.15	1299.21	1.05	0.54	28600.00	46.96	119.46	61.14
SC62AB	279.0	25.47	36.70	12.13	9494.17	1843.32	1.77	1.16	65100.00	41.67	230.33	126.33
SC62CD	256.0	100.60	14.89	26.60	3147.63	1840.62	0.04	0.34	118000.00	37.03	179.67	65.03
SC63	117.0	144.98	7.24	26.37	405.99	1464.46	1.45	0.41	1200.00	52.32	104.06	123.20
SC64	114.0	145.62	10.16	35.20	503.14	2659.64	1.42	0.36	1200.00	34.38	108.26	123.16
SC65	42.0	193.02	8.51	34.03	566.82	2722.48	1.69	2.08	2000.00	29.20	128.60	224.20
SC66	22.0	109.10	7.37	17.53	912.46	1264.15	0.80	0.95	700.00	31.94	132.80	187.00
SC67	52.0	73.40	7.06	20.16	250.53	1078.61	0.94	0.99	800.00	46.56	108.74	121.42
SC68	77.0	59.43	6.68	11.50	376.49	578.77	0.88	0.22	1200.00	18.43	129.30	72.08
SC69	402.0	171.83	19.00	9.53	5745.95	1941.23	1.62	1.20	71400.00	35.28	200.00	77.23
SC70	136.0	282.80	3.32	38.61	544.28	946.10	1.33	0.27	3200.00	24.68	139.20	86.22
SC71A	143.0	27.70	45.54	4.86	7155.03	802.20	2.10	0.16	43600.00	43.74	301.20	99.10
SC71BC	95.0	244.40	2.90	39.17	542.70	852.33	1.63	0.28	6300.00	28.42	174.60	104.20
SC72A	73.0	235.00	3.77	49.03	349.70	1102.47	2.98	0.37	1200.00	38.05	199.00	88.75
SC72BC	160.0	21.43	50.20	7.04	16041.00	2021.00	5.03	0.30	39900.00	96.47	149.67	124.83
SC73	422.0	94.70	6.83	22.45	42.05	1255.65	542.13	0.26	2700.00	58.80	205.40	158.50
SC74	229.0	128.02	22.60	44.03	3953.53	4084.88	0.86	0.39	800.00	46.06	147.20	131.00
SC75	66.0	41.20	4.95	9.11	101.83	478.72	0.51	0.36	12200.00	42.12	119.30	99.64
SC76	240.0	100.62	6.76	20.23	109.59	1022.11	318.55	0.47	2700.00	41.98	182.00	143.60
SC77	582.0	127.40	5.51	15.04	181.89	922.43	1.70	0.24	1600.00	35.29	172.57	117.01
SC78	207.0	132.21	88.84	72.13	31858.79	5658.79	1.26	0.23	2900.00	44.16	270.29	116.37
SC79	340.0	59.86	8.89	27.63	207.81	1311.51	0.60	0.18	23300.00	35.11	673.00	29.26
SC80	1622.0	182.56	12.56	54.29	380.58	3956.68	0.71	0.28	4300.00	48.41	117.33	141.00
SC81ABCD	1117.0	114.39	13.90	8.25	3276.27	902.26	0.71	0.30	117000.00	35.17	129.86	89.73
SC82	896.0	247.88	3.73	65.37	245.43	1723.15	0.75	0.63	4000.00	61.81	110.83	108.43
SC83	287.0	214.04	5.57	19.19	252.50	1411.59	2.02	0.13	2200.00	43.04	114.60	102.82
SC84	261.0	121.04	4.97	17.15	255.32	895.07	121.93	0.41	1500.00	28.68	120.74	155.02
SC85	78.0	152.44	7.26	29.31	908.10	1752.40	0.75	0.65	2200.00	35.76	122.54	149.00
SC86	112.0	89.42	5.10	23.77	295.21	928.20	0.65	0.28	800.00	44.22	124.40	125.60
SC87	168.0	215.94	7.23	42.67	693.30	2464.52	344.65	1.18	1000.00	40.48	208.80	124.90

E.C. = Electrical Conductivity (dS/m); SAR = Sodium Adsorption Ratio (calculated after averages taken);
N/A = Data Not Available.

(Continued). Mean Values for Selected Properties of the Drilling Waste Solid Samples.

Sump Number	Cr	Ni	Cd	Pb
		(mg/kg)		
SC47	112.30	56.06	0.22	92.39
SC48	97.80	56.06	0.20	81.08
SC49	51.60	37.68	0.20	37.29
SC50	118.43	57.38	0.33	45.81
SC51	105.98	43.56	0.16	38.06
SC52A	43.40	18.83	0.06	27.47
SC52C	81.85	36.60	0.06	34.00
SC53	82.62	32.40	0.94	37.14
SC54	93.20	35.97	0.53	44.23
SC55	75.98	29.26	0.11	59.36
SC56A	145.50	22.45	0.06	64.10
SC56B	88.36	31.54	0.42	51.78
SC56C	107.00	21.20	1.18	45.30
SC57	71.24	43.00	0.52	156.04
SC58	81.48	29.64	0.18	42.53
SC59	92.50	43.88	0.42	55.13
SC60	94.67	53.92	0.52	29.71
SC61	43.80	32.94	0.56	90.57
SC62AB	77.63	46.00	0.28	58.72
SC62CD	42.07	28.70	0.43	202.57
SC63	74.60	47.06	0.06	42.03
SC64	102.52	43.84	0.80	63.42
SC65	104.00	52.72	1.01	46.30
SC66	92.92	45.62	0.45	59.09
SC67	75.56	39.44	0.23	57.22
SC68	52.82	27.53	0.38	42.76
SC69	69.17	37.08	0.54	115.61
SC70	69.76	31.24	0.64	114.99
SC71A	79.82	42.62	0.19	29.47
SC71BC	76.32	39.06	0.81	155.17
SC72A	85.00	49.40	1.00	186.32
SC72BC	80.30	55.03	0.61	92.66
SC73	103.08	62.54	0.77	624.28
SC74	87.78	54.74	0.52	75.85
SC75	87.38	50.50	0.41	122.92
SC76	87.48	52.34	0.76	41.36
SC77	87.83	39.44	0.27	41.31
SC78	242.21	32.73	0.75	52.33
SC79	36.70	25.72	0.06	119.42
SC80	100.28	57.87	0.51	112.31
SC81ABCD	71.53	40.09	0.27	200.02
SC82	125.70	51.04	0.06	63.71
SC83	98.60	49.74	0.47	119.84
SC84	89.22	38.94	0.88	71.52
SC85	85.02	44.74	0.42	71.91
SC86	82.38	50.10	0.32	107.06
SC87	206.28	43.54	1.30	39.41
SC87	206.28	43.54	1.30	39.41

(Continued). Mean Values for Selected Properties of the Drilling Waste Solid Samples.

Sump	Solid	H2O	E.C.	SAR	Cl	Na	NO3&NH4-N	B	Oil	Cu	Zn	V
Number	Vol,m3	(%)	(dS/m)	postcalc	-----------------------------			(mg/Kg)	------------------------------			
SC88	275.0	289.80	9.63	39.30	2908.48	3234.22	2.99	3.19	14400.00	57.86	140.00	261.20
SC89	60.0	102.60	8.74	33.88	518.47	1919.75	0.63	0.65	600.00	63.78	717.20	134.80
SC90	41.0	93.28	7.32	30.88	630.78	1590.07	0.97	1.32	800.00	31.00	109.44	119.36
SC91	487.0	133.03	9.14	25.88	900.55	2035.35	228.50	2.01	2700.00	34.88	211.33	176.50
SC92	96.0	44.26	6.03	25.51	210.49	1014.87	2.49	1.03	800.00	22.32	189.80	102.38
SC93	501.0	83.74	24.58	85.75	4949.40	3736.15	1.90	0.36	16000.00	91.02	22.22	14.48
SC94	226.0	113.64	6.77	30.81	1148.93	1688.28	1.61	0.70	800.00	31.38	88.08	104.52
SC95	2259.0	167.89	8.00	72.12	297.90	2837.75	1.34	0.20	2000.00	65.00	1028.50	101.19
SC96	N/A	14.42	7.04	23.25	246.92	898.77	0.69	0.21	1000.00	50.22	174.60	100.00
SC97	349.0	122.35	7.63	27.29	234.16	1185.13	1.83	0.10	2200.00	61.60	142.00	148.50
SC98	735.0	102.80	58.30	24.47	45628.64	4788.34	3.80	0.03	1300.00	63.01	84.41	116.14
SC99	340.0	193.72	34.45	10.06	10785.30	2240.51	3.57	0.20	82900.00	56.42	161.55	108.42
SC100	134.0	90.82	11.25	22.83	2215.27	1491.20	1.06	0.24	1000.00	22.00	129.32	126.72
SC101	188.0	102.74	6.02	17.20	499.40	1316.03	1.61	0.37	500.00	47.98	145.60	162.00
SC102	87.0	151.24	83.22	36.97	27399.40	2440.86	16.32	0.01	500.00	36.88	119.28	105.34
SC103	189.0	83.66	12.03	35.51	951.15	1933.54	0.30	0.48	1200.00	31.34	303.40	163.20
SC104	314.0	178.04	8.46	22.77	582.76	1603.50	0.32	0.63	1900.00	35.00	248.60	142.80
SC105	308.0	125.34	38.44	24.72	9812.90	2392.84	0.46	0.02	500.00	32.36	118.80	127.80
SC106	285.0	228.54	40.22	30.91	13475.56	4066.92	0.38	0.05	700.00	34.40	125.20	141.54
SC107	780.0	68.04	49.02	6.16	12688.53	225.81	0.97	0.01	8500.00	35.96	616.80	99.44
SC108	1554.0	119.62	18.96	17.48	5174.12	1694.82	0.71	1.66	62450.00	67.45	1366.15	45.53
SC200	216.0	891.80	13.08	51.29	557.26	6117.80	0.14	0.69	19000.00	72.06	2488.00	77.54
SC201	287.0	115.18	7.96	21.67	1487.85	1242.24	0.77	0.18	6200.00	38.24	152.00	163.80
SC202	10395.0	261.13	11.58	43.46	381.07	4231.68	0.13	0.26	24500.00	77.85	2747.88	53.70
SC203	1234.0	301.03	7.94	29.40	847.70	2667.65	0.27	0.18	500.00	28.40	120.98	46.82
SC205	16.0	79.04	22.73	12.08	5850.75	844.88	1.91	0.32	1000.00	33.20	127.80	96.38
SC206	214.0	188.40	130.20	1168.46	109299.00	62206.00	2.81	0.04	7000.00	30.30	129.12	55.36

E.C. = Electrical Conductivity (dS/m); SAR = Sodium Adsorption Ratio (calculated after averages taken);
N/A = Data Not Available.

(Concluded). Mean Values for Selected Properties of the Drilling Waste Solid Samples.

Sump Number	Cr	Ni	Cd	Pb
	----------	(mg/kg)		----------
SC88	119.20	71.00	1.68	131.11
SC89	83.30	69.00	1.17	87.67
SC90	75.30	39.26	0.48	188.68
SC91	88.17	42.63	1.15	39.35
SC92	66.72	32.26	0.77	20.07
SC93	33.86	8.00	0.06	11.76
SC94	65.10	36.10	1.06	23.63
SC95	94.53	71.76	0.58	78.37
SC96	72.78	57.02	0.06	80.98
SC97	102.72	66.53	0.55	58.57
SC98	91.76	71.13	0.64	81.73
SC99	74.78	59.61	0.27	76.96
SC100	79.28	33.44	0.10	78.81
SC101	97.08	57.58	1.37	72.22
SC102	79.10	37.72	0.06	70.69
SC103	90.80	42.96	0.52	38.63
SC104	90.66	45.14	0.78	107.87
SC105	102.20	97.20	1.42	49.29
SC106	84.80	42.84	0.32	50.00
SC107	63.28	37.82	0.84	67.61
SC108	39.59	24.00	0.67	49.63
SC200	88.46	41.44	2.73	175.02
SC201	94.36	49.52	1.09	75.45
SC202	64.68	31.54	1.37	132.10
SC203	41.47	35.43	0.63	82.50
SC205	68.40	42.30	0.30	54.29
SC206	290.40	24.22	0.20	122.00

APPENDIX 17: APPLICATION RATES FOR THE DRILLING WASTE SOLIDS (SCENARIO 4)

Application Rates for the Drilling Waste Solids (Scenario 4).

Sump Number	Solid Vol, m3	Calc Wet BD g/cm3	EC	SAR	Cl	Na	NO3-N & NH4-N	B	Oil 10000	Oil 20000	Cu	Zn
			(m3 wet/ha)									
SC3	N/A	0.622	1060.0	1470.0	37100.0	1030.0	410000	104000	32100.0	64300	13700	491
SC4	N/A	1.590	184.0	546.0	334.0	588.0	1060000	165000	4180.0	8360	6140	411
SC5	N/A	1.880	89.8	116.0	519.0	303.0	8900000	74800	2960.0	5910	9500	339
SC6	N/A	1.650	50.2	1020.0	44.6	186.0	26400	27800	76.7	153	3540	952
SC7	N/A	0.283	6510.0	2120.0	4570.0	2170.0	10100000	297000	9560.0	19100	22100	12700
SC8	N/A	1.620	443.0	205.0	16400.0	372.0	1130000	41000	4740.0	9490	2820	1410
SC9A	430.0	0.199	1290.0	3510.0	794.0	716.0	1940000	140000	609.0	1220	23300	690
SC9BD	166.0	0.319	384.0	1910.0	273.0	460.0	1300000	510000	422.0	845	14200	222
SC9C	189.0	1.250	61.6	1150.0	62.8	234.0	86700	49100	93.0	186	3890	1480
SC10	612.0	0.728	620.0	559.0	15000.0	445.0	806000	85500	8080.0	16200	6340	3850
SC11	157.0	0.431	1510.0	1040.0	4790.0	723.0	151000	18700	12900.0	25800	8230	5870
SC12	53.5	0.787	102.0	1430.0	95.9	542.0	336000	22600	25400.0	50800	5670	4030
SC13	110.0	0.408	227.0	87.8	213.0	215.0	16800	40500	27200.0	54500	7870	6200
SC14A	46.0	1.300	656.0	538.0	1550.0	546.0	271000	39000	9590.0	19200	10700	1420
SC14B	100.0	1.030	1230.0	866.0	4220.0	733.0	697000	104000	6470.0	12900	9820	2480
SC15	183.0	0.738	791.0	780.0	12700.0	569.0	585000	43800	22600.0	45200	10000	4060
SC16	135.0	0.645	867.0	509.0	6330.0	342.0	794000	10500	10300.0	20700	7950	3360
SC17	120.0	0.589	819.0	889.0	2910.0	457.0	958000	13300	9430.0	18900	7090	3630
SC18	205.0	0.452	1070.0	1340.0	1030.0	655.0	722000	85700	11100.0	22100	17600	5620
SC19B	880.0	1.210	161.0	596.0	180.0	278.0	876000	567000	797.0	1590	3990	1930
SC19C	402.0	1.350	227.0	716.0	348.0	485.0	1710000	247000	644.0	1290	2760	1310
SC21	590.0	0.695	622.0	857.0	1140.0	432.0	340000	9030	6260.0	12500	9590	3480
SC22	N/A	0.463	1060.0	982.0	850.0	356.0	92100	6070	2300.0	4600	13400	5890
SC23	N/A	0.507	951.0	316.0	1070.0	310.0	5630000	4440	2120.0	4240	10400	5160
SC24	1148.2	0.486	1130.0	1440.0	9040.0	800.0	653000	65200	13700.0	27400	11900	3800
SC25	373.0	0.606	778.0	640.0	2900.0	424.0	392000	23200	16500.0	33000	12200	4800
SC26	672.0	0.610	987.0	1830.0	3390.0	926.0	15500	28700	12600.0	25200	10400	4390
SC27	288.0	0.712	868.0	1610.0	7500.0	966.0	1510	26300	9360.0	18700	9290	4190
SC28	571.0	0.594	529.0	960.0	200.0	372.0	408000	13500	11200.0	22400	17300	5280
SC29	600.0	0.510	107.0	276.0	70.1	52.8	585000	39200	6760.0	13500	12100	6560
SC30A	2.4	0.640	1080.0	2560.0	3700.0	1180.0	478000	24300	6790.0	13600	9390	2800
SC32	561.0	0.745	869.0	1550.0	2570.0	835.0	833000	17400	4630.0	9260	10400	4610
SC33	225.0	0.289	1740.0	1680.0	6700.0	776.0	5710000	26000	43300.0	86600	27600	4630
SC34	1750.0	0.322	2100.0	1010.0	11200.0	839.0	1810000	51800	38800.0	77700	16900	8260
SC35	3643.0	0.495	933.0	756.0	6350.0	455.0	1540000	68400	25300.0	50500	10700	5340
SC36	501.0	0.693	95.7	1220.0	85.9	461.0	368000	284000	14400.0	28900	7760	3460
SC37	383.0	0.621	1630.0	619.0	9070.0	975.0	2340000	48900	23000.0	46000	10600	4100
SC38	278.0	1.240	682.0	424.0	7360.0	635.0	586000	40600	16100.0	32300	6100	2210
SC39	639.0	0.426	1210.0	1830.0	2800.0	876.0	700000	101000	46900.0	93900	14400	6160
SC40	1639.0	0.379	702.0	659.0	1240.0	251.0	810000	45300	8260.0	16500	16100	1660
SC41	681.0	0.198	1220.0	1320.0	1620.0	501.0	1850000	112000	1300.0	2600	30000	5610
SC42	133.0	0.890	492.0	809.0	3440.0	572.0	379000	34400	16100.0	32100	5190	2440
SC43	382.0	0.743	574.0	700.0	2030.0	383.0	1390000	14000	10300.0	20700	7450	4950
SC44	146.0	0.786	743.0	1800.0	1320.0	888.0	538000	14300	12700.0	25400	7050	5160
SC45	768.0	0.654	581.0	1040.0	1000.0	515.0	558000	37600	51000.0	102000	10200	3780
SC46	781.0	0.377	702.0	1700.0	698.0	608.0	534000	110000	17700.0	35400	12600	5610

N/A = Data Not Available.

(Continued). Application Rates for the Drilling Waste Solids (Scenario 4).

Sump Number	V	Cr	Ni	Cd	Pb
	(m3 wet/ha)				
SC3	992	2110	1130	6390	2600
SC4	542	1210	513	7610	638
SC5	1970	3740	1660	2840	1160
SC6	270	980	424	1310	1100
SC7	1900	4080	1820	10300	7340
SC8	214	617	308	758	1140
SC9A	2630	7280	3720	23100	2410
SC9BD	4090	8010	3030	7360	2710
SC9C	355	1120	637	4100	825
SC10	572	1620	780	3290	942
SC11	672	2370	894	4740	1610
SC12	616	1610	625	4200	3940
SC13	427	855	1090	12800	3060
SC14A	367	997	660	2510	1650
SC14B	453	1360	681	2090	3960
SC15	587	2070	913	3130	2650
SC16	478	1640	876	10300	2560
SC17	552	1860	811	4050	2770
SC18	908	2500	1650	2080	1860
SC19B	395	985	493	3130	1060
SC19C	382	911	425	2120	1020
SC21	448	1700	788	3910	2160
SC22	782	1250	1240	8660	4990
SC23	555	1140	1050	2360	2350
SC24	736	2120	1020	6420	2140
SC25	710	2110	938	11300	3710
SC26	579	1870	915	6770	3740
SC27	573	1860	876	3970	3540
SC28	833	2410	1480	40400	1860
SC29	1280	2930	1490	6580	2950
SC30A	704	2200	940	5240	1720
SC32	724	2300	949	11600	8610
SC33	1160	2820	2500	2380	8930
SC34	1370	3260	2210	19300	5180
SC35	985	1700	1660	3510	2520
SC36	500	1460	781	5390	3860
SC37	571	1750	1000	2010	2630
SC38	371	1060	548	838	1350
SC39	786	2350	1370	7230	8960
SC40	1120	1900	1640	15200	7290
SC41	3790	11000	3350	121000	4030
SC42	394	1530	480	1910	1930
SC43	555	1730	639	13500	4010
SC44	551	2350	673	30500	5740
SC45	605	1150	842	3710	3040
SC46	815	2480	1080	4940	6380

(Continued). Application Rates for the Drilling Waste Solids (Scenario 4).

Sump Number	Solid Vol, m3	Calc Wet BD g/cm3	EC	SAR	Cl	Na	NO3-N & NH4-N	B	Oil 10000	Oil 20000	Cu	Zn
			(m3 wet/ha)									
SC47	553.0	0.650	553.0	683.0	2300.0	297.0	102000	37200	14000.0	28000	7190	3020
SC48	551.0	0.423	1940.0	2810.0	6020.0	1630.0	833000	225000	5620.0	11200	10400	5430
SC49	1107.0	0.746	495.0	459.0	2020.0	297.0	630000	26900	7890.0	15800	7570	5640
SC50	828.0	0.476	1100.0	1530.0	5010.0	763.0	846000	65100	17500.0	35000	8300	5280
SC51	N/A	0.769	557.0	720.0	12900.0	425.0	605	31300	18600.0	37200	8100	3030
SC52A	N/A	1.030	37.6	27.9	17.0	16.3	262000	47600	2620.0	5230	24600	7220
SC52C	N/A	0.619	1140.0	1660.0	7050.0	915.0	278000	45200	53800.0	108000	12400	4570
SC53	230.0	0.701	209.0	1740.0	214.0	783.0	892000	56000	7920.0	15800	10400	3700
SC54	477.0	0.888	700.0	762.0	8320.0	468.0	308000	18400	7510.0	15000	6140	2790
SC55	577.0	0.900	657.0	681.0	10700.0	417.0	263000	49600	9260.0	18500	8490	1890
SC56A	88.0	0.261	85.5	177.0	44.0	120.0	995000	554000	4500.0	9000	21700	3970
SC56B	315.0	0.490	68.9	248.0	45.4	168.0	562000	1480000	4750.0	9490	13000	3130
SC56C	17.0	0.361	100.0	688.0	52.0	148.0	298000	1520000	1530.0	3060	18500	3780
SC57	423.0	1.330	61.0	1140.0	48.8	166.0	60900	76000	95.3	191	2410	1210
SC58	401.0	0.587	153.0	909.0	144.0	430.0	680000	215000	5160.0	10300	12500	2730
SC59	346.0	0.674	184.0	1020.0	182.0	564.0	409000	605000	29700.0	59300	7920	4100
SC60	320.0	0.788	440.0	207.0	905.0	1000.0	366000	226000	8470.0	16900	5770	2010
SC61	755.0	1.510	98.5	841.0	105.0	255.0	253000	12200	232.0	463	2820	1660
SC62AB	279.0	1.510	63.1	798.0	55.9	180.0	150000	5720	102.0	204	3190	865
SC62CD	256.0	0.737	324.0	709.0	345.0	369.0	12400000	39800	115.0	230	7330	2270
SC63	117.0	0.547	934.0	965.0	3600.0	624.0	503000	44300	15200.0	30500	6990	5270
SC64	114.0	0.545	653.0	718.0	2920.0	345.0	519000	51700	15300.0	30600	10700	5090
SC65	42.0	0.433	991.0	935.0	3260.0	424.0	547000	11100	11500.0	23100	15800	5380
SC66	22.0	0.680	736.0	1190.0	1290.0	582.0	737000	15600	21000.0	42000	9210	3320
SC67	52.0	0.898	584.0	778.0	3560.0	516.0	476000	11300	13900.0	27800	4790	3070
SC68	77.0	1.030	542.0	1240.0	2070.0	842.0	444000	45200	8120.0	16200	10600	2260
SC69	402.0	0.492	378.0	3190.0	283.0	524.0	501000	17000	285.0	569	11500	3050
SC70	136.0	0.312	3910.0	1140.0	4710.0	1690.0	965000	120000	10000.0	20000	25900	6900
SC71A	143.0	1.480	51.6	2340.0	75.6	421.0	129000	41600	155.0	310	3090	673
SC71BC	95.0	0.355	4040.0	986.0	4150.0	1650.0	691000	102000	4470.0	8930	19800	4830
SC72A	73.0	0.367	2870.0	760.0	6240.0	1240.0	367000	74500	22700.0	45500	14300	4110
SC72BC	160.0	1.630	42.5	1360.0	30.6	152.0	48800	20500	154.0	308	1270	1230
SC73	422.0	0.754	721.0	828.0	25200.0	528.0	979	51500	4910.0	9830	4510	1940
SC74	229.0	0.602	258.0	516.0	336.0	203.0	774000	42600	20700.0	41500	7210	3380
SC75	66.0	1.260	615.0	1310.0	6250.0	831.0	619000	22300	652.0	1300	3780	2000
SC76	240.0	0.722	761.0	964.0	10100.0	678.0	1740	29700	5130.0	10300	6600	2280
SC77	582.0	0.605	1140.0	1570.0	7270.0	896.0	388000	68700	10300.0	20700	9370	2870
SC78	207.0	0.588	66.2	320.0	42.7	150.0	541000	73300	5860.0	11700	7700	1890
SC79	340.0	1.020	402.0	493.0	3780.0	374.0	653000	56100	421.0	843	5590	438
SC80	1622.0	0.454	628.0	553.0	4630.0	278.0	1240000	79700	5120.0	10200	9090	5630
SC81ABCD	1117.0	0.675	380.0	2730.0	362.0	821.0	835000	48900	127.0	253	8420	3420
SC82	896.0	0.351	3040.0	593.0	9300.0	827.0	1520000	45000	7130.0	14300	9230	7720
SC83	287.0	0.397	1710.0	1850.0	7980.0	892.0	498000	197000	11400.0	22900	11700	6590
SC84	261.0	0.629	1220.0	1320.0	4980.0	888.0	5210	38900	10600.0	21200	11100	3950
SC85	78.0	0.526	968.0	899.0	1680.0	543.0	1020000	29300	8650.0	17300	10600	4660
SC86	112.0	0.785	954.0	749.0	3450.0	686.0	778000	44800	15900.0	31900	5760	3070
SC87	168.0	0.394	1300.0	815.0	2930.0	515.0	2950	21500	25400.0	50800	12500	3650

N/A = Data Not Available.

(Continued). Application Rates for the Drilling Waste Solids (Scenario 4).

Sump Number	V	Cr	Ni	Cd	Pb
			(m3 wet/ha)		
SC47	444	1370	686	10700	1670
SC48	901	2410	1050	17900	2910
SC49	940	2600	889	10200	3600
SC50	686	1770	915	9610	4580
SC51	335	1230	747	12200	3420
SC52A	1260	2230	1290	23200	3520
SC52C	581	1970	1100	38700	4750
SC53	451	1730	1100	2270	3840
SC54	317	1210	783	3200	2550
SC55	478	1460	949	15400	1870
SC56A	1820	2630	4260	91800	5970
SC56B	792	2310	1620	7220	3940
SC56C	1100	2590	3270	3520	6110
SC57	450	1050	436	2180	481
SC58	690	2090	1440	14300	4010
SC59	541	1600	845	5350	2690
SC60	488	1340	589	3660	4270
SC61	542	1510	503	1780	732
SC62AB	263	855	361	3560	1130
SC62CD	1040	3230	1180	4760	670
SC63	742	2450	972	43900	4350
SC64	745	1790	1050	3450	2890
SC65	515	2220	1090	3410	4980
SC66	393	1580	806	4900	2490
SC67	459	1470	706	7280	1950
SC68	676	1850	885	3880	2280
SC69	1320	2940	1370	5640	1760
SC70	1860	4590	2560	7550	2780
SC71A	341	847	397	5450	2290
SC71BC	1350	3690	1800	5190	1810
SC72A	1540	3210	1380	4100	1460
SC72BC	246	765	279	1510	663
SC73	418	1290	530	2580	212
SC74	633	1890	758	4780	2190
SC75	399	911	394	2910	647
SC76	482	1580	662	2750	3350
SC77	706	1880	1050	9240	4000
SC78	731	702	1300	3420	3250
SC79	1680	2670	954	23600	822
SC80	780	2190	951	6440	1960
SC81ABCD	825	2070	923	8180	740
SC82	1320	2270	1400	68400	4480
SC83	1220	2550	1270	7950	2100
SC84	513	1780	1020	2700	2220
SC85	638	2240	1060	6850	2650
SC86	507	1550	636	5890	1190
SC87	1020	1230	1460	2940	6440

(Continued). Application Rates for the Drilling Waste Solids (Scenario 4).

Sump Number	Solid Vol, m3	Calc Wet BD g/cm3	EC	SAR	Cl	Na	NO3-N & NH4-N	B	Oil 10000	Oil 20000	Cu	Zn
			(m3 wet/ha)									
SC88	275.0	0.308	1220.0	1130.0	893.0	502.0	434000	10200	2260.0	4510	11200	6960
SC89	60.0	0.711	587.0	572.0	2170.0	366.0	891000	21600	23400.0	46900	4410	588
SC90	41.0	0.762	662.0	588.0	1660.0	413.0	544000	9980	16400.0	32800	8470	3600
SC91	487.0	0.585	681.0	919.0	1520.0	420.0	2990	8480	6330.0	12700	9800	2430
SC92	96.0	1.220	512.0	449.0	3130.0	405.0	132000	8010	10300.0	20600	7370	1300
SC93	501.0	0.823	174.0	192.0	197.0	163.0	255000	33300	760.0	1520	2670	16400
SC94	226.0	0.660	832.0	680.0	1060.0	449.0	377000	21700	19000.0	37900	9660	5160
SC95	2259.0	0.486	943.0	387.0	5520.0	362.0	615000	104000	10300.0	20600	6330	600
SC96	N/A	1.910	276.0	316.0	1700.0	292.0	302000	24800	5250.0	10500	2090	902
SC97	349.0	0.624	773.0	816.0	5470.0	676.0	349000	168000	7280.0	14600	5200	3390
SC98	735.0	0.710	83.8	802.0	24.7	147.0	148000	493000	10800.0	21700	4470	5000
SC99	340.0	0.449	225.0	3280.0	165.0	497.0	250000	112000	268.0	537	7890	4130
SC100	134.0	0.776	412.0	790.0	465.0	432.0	486000	53800	12900.0	25800	11700	2990
SC101	188.0	0.711	877.0	1160.0	2250.0	535.0	350000	37900	28100.0	56300	5870	2900
SC102	87.0	0.529	78.7	704.0	55.2	388.0	46400	1440000	37800.0	75700	10300	4760
SC103	189.0	0.822	363.0	472.0	1020.0	315.0	1610000	25100	10100.0	20300	7760	1200
SC104	314.0	0.463	933.0	1330.0	2960.0	673.0	2660000	34000	11400.0	22700	12300	2600
SC105	308.0	0.612	148.0	921.0	133.0	341.0	1420000	683000	32700.0	65300	10100	4120
SC106	285.0	0.375	228.0	1177.0	158.0	328.0	2810000	533000	38100.0	76200	15500	6390
SC107	780.0	0.943	75.2	2750.0	66.9	2350.0	439000	945000	1250.0	2500	5900	516
SC108	1554.0	0.646	289.0	1260.0	239.0	457.0	875000	9350	248.0	496	4590	340
SC200	216.0	0.109	2500.0	2430.0	13100.0	747.0	25700000	132000	4810.0	9630	25400	1100
SC201	287.0	0.654	705.0	990.0	822.0	616.0	796000	85100	2470.0	4930	8000	3020
SC202	10395.0	0.339	915.0	929.0	6190.0	348.0	9080000	114000	1200.0	2410	7570	322
SC203	1234.0	0.295	1570.0	1600.0	3200.0	635.0	5050000	186000	67800.0	136000	23900	8400
SC205	16.0	0.854	181.0	1410.0	160.0	693.0	245000	36300	11700.0	23400	7050	2750
SC206	214.0	0.443	59.8	25.9	16.5	18.1	322000	540000	3220.0	6450	14900	5240

N/A = Data Not Available.

(Concluded). Application Rates for the Drilling Waste Solids (Scenario 4).

Sump Number	V	Cr	Ni	Cd	Pb
	----------- (m3 wet/ha) ------------				
SC88	622	2720	1140	2900	2480
SC89	521	1690	509	1800	1600
SC90	550	1740	836	4130	696
SC91	484	1940	1000	2240	4340
SC92	402	1230	638	1610	4100
SC93	4200	3590	3800	29200	10300
SC94	725	2330	1050	2140	6420
SC95	1020	2180	717	5320	2620
SC96	262	721	230	12600	648
SC97	540	1560	602	4380	2740
SC98	606	1530	495	3320	1720
SC99	1030	2980	933	12600	2890
SC100	508	1620	963	18600	1630
SC101	434	1450	611	1540	1950
SC102	898	2390	1250	45400	2680
SC103	373	1340	708	3540	3150
SC104	756	2380	1200	4180	2000
SC105	639	1600	420	1730	3310
SC106	942	3140	1560	12500	5330
SC107	533	1680	701	1890	1570
SC108	1700	3910	1610	3470	3120
SC200	5900	10300	5520	5020	5230
SC201	467	1620	772	2100	2030
SC202	2740	4560	2340	3230	2230
SC203	3620	8170	2390	8110	4110
SC205	607	1710	692	5780	2160
SC206	2040	777	2330	17300	1850

APPENDIX 18: AREAS REQUIRED FOR THE LAND APPLICATION OF THE DRILLING WASTE SOLIDS (SCENARIO 4)

Areas Required for Land Application of the Drilling Waste Solids (Scenario 4).

Sump Number	Solid Vol, m3	Calc Wet BD g/cm3	EC	SAR	Cl	Na	NO3-N& NH4-N	B	Oil 10000	Oil 20000	Cu	Zn	V	Cr
			(ha)											
SC3	N/A	0.622												
SC4	N/A	1.590												
SC5	N/A	1.880												
SC6	N/A	1.650												
SC7	N/A	0.283												
SC8	N/A	1.620												
SC9A	430.0	0.199	0.334	0.122	0.54	0.60	0.00	0.00	0.71	0.35	0.02	0.62	0.16	0.06
SC9BD	166.0	0.319	0.433	0.087	0.61	0.36	0.00	0.00	0.39	0.20	0.01	0.75	0.04	0.02
SC9C	189.0	1.250	3.070	0.164	3.01	0.81	0.00	0.00	2.03	1.02	0.05	0.13	0.53	0.17
SC10	612.0	0.728	0.987	1.090	0.04	1.38	0.00	0.01	0.08	0.04	0.10	0.16	1.07	0.38
SC11	157.0	0.431	0.104	0.152	0.03	0.22	0.00	0.01	0.01	0.01	0.02	0.03	0.23	0.07
SC12	53.5	0.787	0.526	0.037	0.56	0.10	0.00	0.00	0.00	0.00	0.01	0.01	0.09	0.03
SC13	110.0	0.408	0.484	1.250	0.52	0.51	0.01	0.00	0.00	0.00	0.01	0.02	0.26	0.13
SC14A	46.0	1.300	0.070	0.086	0.03	0.08	0.00	0.00	0.00	0.00	0.00	0.03	0.13	0.05
SC14B	100.0	1.030	0.081	0.116	0.02	0.14	0.00	0.00	0.02	0.01	0.01	0.04	0.22	0.07
SC15	183.0	0.738	0.231	0.235	0.01	0.32	0.00	0.00	0.01	0.00	0.02	0.05	0.31	0.09
SC16	135.0	0.645	0.156	0.265	0.02	0.40	0.00	0.01	0.01	0.01	0.02	0.04	0.28	0.08
SC17	120.0	0.589	0.147	0.135	0.04	0.26	0.00	0.01	0.01	0.01	0.02	0.03	0.22	0.06
SC18	205.0	0.452	0.192	0.153	0.20	0.31	0.00	0.00	0.02	0.01	0.01	0.04	0.23	0.08
SC19B	880.0	1.210	5.450	1.480	4.89	3.16	0.00	0.00	1.10	0.55	0.22	0.46	2.23	0.89
SC19C	402.0	1.350	1.770	0.562	1.16	0.83	0.00	0.00	0.62	0.31	0.15	0.31	1.05	0.44
SC21	590.0	0.695	0.949	0.688	0.52	1.36	0.00	0.07	0.09	0.05	0.06	0.17	1.32	0.35
SC22	N/A	0.463												
SC23	N/A	0.507												
SC24	1148.2	0.486	1.010	0.800	0.13	1.44	0.00	0.02	0.08	0.04	0.10	0.30	1.56	0.54
SC25	373.0	0.606	0.479	0.583	0.13	0.88	0.00	0.02	0.02	0.01	0.03	0.08	0.53	0.18
SC26	672.0	0.610	0.681	0.367	0.20	0.73	0.04	0.02	0.05	0.03	0.06	0.15	1.16	0.36
SC27	288.0	0.712	0.332	0.179	0.04	0.30	0.19	0.01	0.03	0.02	0.03	0.07	0.50	0.16
SC28	571.0	0.594	1.080	0.595	2.86	1.53	0.00	0.04	0.05	0.03	0.03	0.11	0.69	0.24
SC29	600.0	0.510	5.630	2.170	8.56	11.40	0.00	0.02	0.09	0.04	0.05	0.09	0.47	0.21
SC30A	2.4	0.640	0.002	0.001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC32	561.0	0.745	0.645	0.362	0.22	0.67	0.00	0.03	0.12	0.06	0.05	0.12	0.78	0.24
SC33	225.0	0.289	0.129	0.134	0.03	0.29	0.00	0.01	0.01	0.00	0.01	0.05	0.20	0.08
SC34	1750.0	0.322	0.832	1.730	0.16	2.09	0.00	0.03	0.05	0.02	0.10	0.21	1.28	0.54
SC35	3643.0	0.495	3.910	4.820	0.57	8.00	0.00	0.05	0.14	0.07	0.34	0.68	3.70	2.14
SC36	501.0	0.693	5.240	0.410	5.84	1.09	0.00	0.00	0.03	0.02	0.06	0.15	1.00	0.34
SC37	383.0	0.621	0.235	0.619	0.04	0.39	0.00	0.01	0.02	0.01	0.04	0.09	0.67	0.22
SC38	278.0	1.240	0.407	0.656	0.04	0.44	0.00	0.01	0.02	0.01	0.05	0.13	0.75	0.26
SC39	639.0	0.426	0.529	0.350	0.23	0.73	0.00	0.01	0.01	0.01	0.04	0.10	0.81	0.27
SC40	1639.0	0.379	2.330	2.490	1.32	6.52	0.00	0.04	0.20	0.10	0.10	0.99	1.46	0.86
SC41	681.0	0.198	0.557	0.515	0.42	1.36	0.00	0.01	0.52	0.26	0.02	0.12	0.18	0.06
SC42	133.0	0.890	0.270	0.164	0.04	0.23	0.00	0.00	0.01	0.00	0.03	0.05	0.34	0.09
SC43	382.0	0.743	0.666	0.546	0.19	1.00	0.00	0.03	0.04	0.02	0.05	0.08	0.69	0.22
SC44	146.0	0.786	0.197	0.081	0.11	0.16	0.00	0.01	0.01	0.01	0.02	0.03	0.27	0.06
SC45	768.0	0.654	1.320	0.736	0.77	1.49	0.00	0.02	0.02	0.01	0.08	0.20	1.27	0.67
SC46	781.0	0.377	1.110	0.461	1.12	1.28	0.00	0.01	0.04	0.02	0.06	0.14	0.96	0.31
SC47	553.0	0.650	0.999	0.810	0.24	1.86	0.01	0.01	0.04	0.02	0.08	0.18	1.25	0.40

N/A = Data Not Available; Areas could not be calculated where volume data not available.

(Continued). Areas Required for Land Application of the Drilling Waste Solids (Scenario 4).

Sump Number	Ni	Cd	Pb
	------	(ha)	------
SC3			
SC4			
SC5			
SC6			
SC7			
SC8			
SC9A	0.12	0.02	0.18
SC9BD	0.05	0.02	0.06
SC9C	0.30	0.05	0.23
SC10	0.79	0.19	0.65
SC11	0.18	0.03	0.10
SC12	0.09	0.01	0.01
SC13	0.10	0.01	0.04
SC14A	0.07	0.02	0.03
SC14B	0.15	0.05	0.03
SC15	0.20	0.06	0.07
SC16	0.15	0.01	0.05
SC17	0.15	0.03	0.04
SC18	0.12	0.10	0.11
SC19B	1.78	0.28	0.83
SC19C	0.95	0.19	0.39
SC21	0.75	0.15	0.27
SC22			
SC23			
SC24	1.13	0.18	0.54
SC25	0.40	0.03	0.10
SC26	0.73	0.10	0.18
SC27	0.33	0.07	0.08
SC28	0.39	0.01	0.31
SC29	0.40	0.09	0.20
SC30A	0.00	0.00	0.00
SC32	0.59	0.05	0.07
SC33	0.09	0.09	0.03
SC34	0.79	0.09	0.34
SC35	2.19	1.04	1.44
SC36	0.64	0.09	0.13
SC37	0.38	0.19	0.15
SC38	0.51	0.33	0.21
SC39	0.47	0.09	0.07
SC40	1.00	0.11	0.22
SC41	0.20	0.01	0.17
SC42	0.28	0.07	0.07
SC43	0.60	0.03	0.10
SC44	0.22	0.00	0.03
SC45	0.91	0.21	0.25
SC46	0.73	0.16	0.12
SC47	0.81	0.05	0.33

(Continued). Areas Required for Land Application of the Drilling Waste Solids (Scenario 4).

Sump Number	Solid Vol, m3	Calc Wet BD g/cm3	EC	SAR	Cl	Na	NO3-N& NH4-N	B	Oil 10000	Oil 20000	Cu	Zn	V	Cr
								(ha)						
SC48	551.0	0.423	0.284	0.196	0.09	0.34	0.00	0.00	0.10	0.05	0.05	0.10	0.61	0.23
SC49	1107.0	0.746	2.230	2.410	0.55	3.73	0.00	0.04	0.14	0.07	0.15	0.20	1.18	0.43
SC50	828.0	0.476	0.754	0.540	0.17	1.09	0.00	0.01	0.05	0.02	0.10	0.16	1.21	0.47
SC51	N/A	0.769												
SC52A	N/A	1.030												
SC52C	N/A	0.619												
SC53	230.0	0.701	1.100	0.133	1.07	0.29	0.00	0.00	0.03	0.01	0.02	0.06	0.51	0.13
SC54	477.0	0.888	0.681	0.626	0.06	1.02	0.00	0.03	0.06	0.03	0.08	0.17	1.51	0.40
SC55	577.0	0.900	0.879	0.848	0.05	1.38	0.00	0.01	0.06	0.03	0.07	0.31	1.21	0.40
SC56A	88.0	0.261	1.030	0.498	2.00	0.73	0.00	0.00	0.02	0.01	0.00	0.02	0.05	0.03
SC56B	315.0	0.490	4.570	1.270	6.94	1.88	0.00	0.00	0.07	0.03	0.02	0.10	0.40	0.14
SC56C	17.0	0.361	0.170	0.025	0.33	0.12	0.00	0.00	0.01	0.01	0.00	0.00	0.02	0.01
SC57	423.0	1.330	6.940	0.371	8.66	2.55	0.01	0.01	4.44	2.22	0.18	0.35	0.94	0.40
SC58	401.0	0.587	2.620	0.441	2.79	0.93	0.00	0.00	0.08	0.04	0.03	0.15	0.58	0.19
SC59	346.0	0.674	1.880	0.339	1.91	0.61	0.00	0.00	0.01	0.01	0.04	0.08	0.64	0.22
SC60	320.0	0.788	0.728	1.550	0.35	0.32	0.00	0.00	0.04	0.02	0.06	0.16	0.66	0.24
SC61	755.0	1.510	7.660	0.898	7.18	2.96	0.00	0.06	3.26	1.63	0.27	0.45	1.39	0.50
SC62AB	279.0	1.510	4.420	0.350	4.99	1.55	0.00	0.05	2.74	1.37	0.09	0.32	1.06	0.33
SC62CD	256.0	0.737	0.789	0.361	0.74	0.69	0.00	0.01	2.23	1.11	0.03	0.11	0.25	0.08
SC63	117.0	0.547	0.125	0.121	0.03	0.19	0.00	0.00	0.01	0.00	0.02	0.02	0.16	0.05
SC64	114.0	0.545	0.174	0.159	0.04	0.33	0.00	0.00	0.01	0.00	0.01	0.02	0.15	0.06
SC65	42.0	0.433	0.042	0.045	0.01	0.10	0.00	0.00	0.00	0.00	0.00	0.01	0.08	0.02
SC66	22.0	0.680	0.030	0.019	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.01
SC67	52.0	0.898	0.089	0.067	0.01	0.10	0.00	0.00	0.00	0.00	0.01	0.02	0.11	0.04
SC68	77.0	1.030	0.142	0.062	0.04	0.09	0.00	0.00	0.01	0.00	0.01	0.03	0.11	0.04
SC69	402.0	0.492	1.060	0.126	1.42	0.77	0.00	0.02	1.41	0.71	0.03	0.13	0.31	0.14
SC70	136.0	0.312	0.035	0.119	0.03	0.08	0.00	0.00	0.01	0.01	0.01	0.02	0.07	0.03
SC71A	143.0	1.480	2.770	0.061	1.89	0.34	0.00	0.00	0.92	0.46	0.05	0.21	0.42	0.17
SC71BC	95.0	0.355	0.024	0.096	0.02	0.06	0.00	0.00	0.02	0.01	0.00	0.02	0.07	0.03
SC72A	73.0	0.367	0.025	0.096	0.01	0.06	0.00	0.00	0.00	0.00	0.01	0.02	0.05	0.02
SC72BC	160.0	1.630	3.760	0.118	5.22	1.05	0.00	0.01	1.04	0.52	0.13	0.13	0.65	0.21
SC73	422.0	0.754	0.585	0.510	0.02	0.80	0.43	0.01	0.09	0.04	0.09	0.22	1.01	0.33
SC74	229.0	0.602	0.886	0.444	0.68	1.13	0.00	0.01	0.01	0.01	0.03	0.07	0.36	0.12
SC75	66.0	1.260	0.107	0.050	0.01	0.08	0.00	0.00	0.10	0.05	0.02	0.03	0.17	0.07
SC76	240.0	0.722	0.315	0.249	0.02	0.35	0.14	0.01	0.05	0.02	0.04	0.11	0.50	0.15
SC77	582.0	0.605	0.512	0.370	0.08	0.65	0.00	0.01	0.06	0.03	0.06	0.20	0.82	0.31
SC78	207.0	0.588	3.130	0.647	4.85	1.38	0.00	0.00	0.04	0.02	0.03	0.11	0.28	0.30
SC79	340.0	1.020	0.845	0.689	0.09	0.91	0.00	0.01	0.81	0.40	0.06	0.78	0.20	0.13
SC80	1622.0	0.454	2.580	2.940	0.35	5.83	0.00	0.02	0.32	0.16	0.18	0.29	2.08	0.74
SC81ABCD	1117.0	0.675	2.940	0.409	3.09	1.36	0.00	0.02	8.83	4.41	0.13	0.33	1.35	0.54
SC82	896.0	0.351	0.295	1.510	0.10	1.08	0.00	0.02	0.13	0.06	0.10	0.12	0.68	0.40
SC83	287.0	0.397	0.168	0.155	0.04	0.32	0.00	0.00	0.03	0.01	0.02	0.04	0.23	0.11
SC84	261.0	0.629	0.213	0.198	0.05	0.29	0.05	0.01	0.02	0.01	0.02	0.07	0.51	0.15
SC85	78.0	0.526	0.081	0.087	0.05	0.14	0.00	0.00	0.01	0.00	0.01	0.02	0.12	0.03
SC86	112.0	0.785	0.117	0.150	0.03	0.16	0.00	0.00	0.01	0.00	0.02	0.04	0.22	0.07
SC87	168.0	0.394	0.129	0.206	0.06	0.33	0.06	0.01	0.01	0.00	0.01	0.05	0.17	0.14
SC88	275.0	0.308	0.225	0.242	0.31	0.55	0.00	0.03	0.12	0.06	0.02	0.04	0.44	0.10

N/A = Data Not Available; Areas could not be calculated where volume data not available.

(Continued). Areas Required for Land Application of the Drilling Waste Solids (Scenario 4).

Sump	Ni	Cd	Pb
Number	------	(ha)	------
SC48	0.52	0.03	0.19
SC49	1.24	0.11	0.31
SC50	0.91	0.09	0.18
SC51			
SC52A			
SC52C			
SC53	0.21	0.10	0.06
SC54	0.61	0.15	0.19
SC55	0.61	0.04	0.31
SC56A	0.02	0.00	0.01
SC56B	0.20	0.04	0.08
SC56C	0.01	0.00	0.00
SC57	0.97	0.19	0.88
SC58	0.28	0.03	0.10
SC59	0.41	0.06	0.13
SC60	0.54	0.09	0.07
SC61	1.50	0.43	1.03
SC62AB	0.77	0.08	0.25
SC62CD	0.22	0.05	0.38
SC63	0.12	0.00	0.03
SC64	0.11	0.03	0.04
SC65	0.04	0.01	0.01
SC66	0.03	0.00	0.01
SC67	0.07	0.01	0.03
SC68	0.09	0.02	0.03
SC69	0.29	0.07	0.23
SC70	0.05	0.02	0.05
SC71A	0.36	0.03	0.06
SC71BC	0.05	0.02	0.05
SC72A	0.05	0.02	0.05
SC72BC	0.57	0.11	0.24
SC73	0.80	0.16	1.99
SC74	0.30	0.05	0.11
SC75	0.17	0.02	0.10
SC76	0.36	0.09	0.07
SC77	0.56	0.06	0.15
SC78	0.16	0.06	0.06
SC79	0.36	0.01	0.41
SC80	1.71	0.25	0.83
SC81ABCD	1.21	0.14	1.51
SC82	0.64	0.01	0.20
SC83	0.23	0.04	0.14
SC84	0.26	0.10	0.12
SC85	0.07	0.01	0.03
SC86	0.18	0.02	0.09
SC87	0.12	0.06	0.03
SC88	0.24	0.10	0.11

(Continued). Areas Required for Land Application of the Drilling Waste Solids (Scenario 4).

Sump Number	Solid Vol, m3	Calc Wet BD g/cm3	EC	SAR	Cl	Na	NO3-N& NH4-N	B	Oil 10000	Oil 20000	Cu	Zn	V	Cr
								(ha)						
SC89	60.0	0.711	0.102	0.105	0.03	0.16	0.00	0.00	0.00	0.00	0.01	0.10	0.12	0.04
SC90	41.0	0.762	0.062	0.070	0.02	0.10	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.02
SC91	487.0	0.585	0.715	0.530	0.32	1.16	0.16	0.06	0.08	0.04	0.05	0.20	1.01	0.25
SC92	96.0	1.220	0.187	0.214	0.03	0.24	0.00	0.01	0.01	0.00	0.01	0.07	0.24	0.08
SC93	501.0	0.823	2.880	2.610	2.55	3.08	0.00	0.02	0.66	0.33	0.19	0.03	0.12	0.14
SC94	226.0	0.660	0.272	0.332	0.21	0.50	0.00	0.01	0.01	0.01	0.02	0.04	0.31	0.10
SC95	2259.0	0.486	2.390	5.840	0.41	6.23	0.00	0.02	0.22	0.11	0.36	3.76	2.22	1.04
SC96	N/A	1.910												
SC97	349.0	0.624	0.452	0.428	0.06	0.52	0.00	0.00	0.05	0.02	0.07	0.10	0.65	0.22
SC98	735.0	0.710	8.770	0.916	29.80	5.00	0.00	0.00	0.07	0.03	0.17	0.15	1.21	0.48
SC99	340.0	0.449	1.510	0.104	2.06	0.69	0.00	0.00	1.27	0.63	0.04	0.08	0.33	0.11
SC100	134.0	0.776	0.325	0.170	0.29	0.31	0.00	0.00	0.01	0.01	0.01	0.04	0.26	0.08
SC101	188.0	0.711	0.214	0.162	0.08	0.35	0.00	0.00	0.01	0.00	0.03	0.06	0.43	0.13
SC102	87.0	0.529	1.110	0.124	1.57	0.22	0.00	0.00	0.00	0.00	0.01	0.02	0.10	0.04
SC103	189.0	0.822	0.521	0.401	0.19	0.60	0.00	0.01	0.02	0.01	0.02	0.16	0.51	0.14
SC104	314.0	0.463	0.336	0.237	0.11	0.47	0.00	0.01	0.03	0.01	0.03	0.12	0.42	0.13
SC105	308.0	0.612	2.080	0.334	2.31	0.90	0.00	0.00	0.01	0.00	0.03	0.07	0.48	0.19
SC106	285.0	0.375	1.250	0.240	1.80	0.87	0.00	0.00	0.01	0.00	0.02	0.04	0.30	0.09
SC107	780.0	0.943	10.400	0.284	11.70	0.33	0.00	0.00	0.63	0.31	0.13	1.51	1.46	0.47
SC108	1554.0	0.646	5.380	1.240	6.49	3.40	0.00	0.17	6.27	3.13	0.34	4.57	0.91	0.40
SC200	216.0	0.109	0.086	0.089	0.02	0.29	0.00	0.00	0.04	0.02	0.01	0.20	0.04	0.02
SC201	287.0	0.654	0.407	0.290	0.35	0.47	0.00	0.00	0.12	0.06	0.04	0.10	0.62	0.18
SC202	10395.0	0.339	11.400	11.200	1.68	29.90	0.00	0.09	8.64	4.32	1.37	32.30	3.79	2.28
SC203	1234.0	0.295	0.787	0.773	0.39	1.94	0.00	0.01	0.02	0.01	0.05	0.15	0.34	0.15
SC205	16.0	0.854	0.088	0.011	0.10	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.01
SC206	214.0	0.443	3.580	8.280	13.00	11.80	0.00	0.00	0.07	0.03	0.01	0.04	0.11	0.28

N/A = Data Not Available; Areas could not be calculated where volume data not available.

(Concluded). Areas Required for Land Application of the Drilling Waste Solids (Scenario 4).

Sump Number	Ni	Cd	Pb
	------	(ha)	------
SC89	0.12	0.03	0.04
SC90	0.05	0.01	0.06
SC91	0.49	0.22	0.11
SC92	0.15	0.06	0.02
SC93	0.13	0.02	0.05
SC94	0.22	0.11	0.04
SC95	3.15	0.43	0.86
SC96			
SC97	0.58	0.08	0.13
SC98	1.49	0.22	0.43
SC99	0.36	0.03	0.12
SC100	0.14	0.01	0.08
SC101	0.31	0.12	0.10
SC102	0.07	0.00	0.03
SC103	0.27	0.05	0.06
SC104	0.26	0.08	0.16
SC105	0.73	0.18	0.09
SC106	0.18	0.02	0.05
SC107	1.11	0.41	0.50
SC108	0.96	0.45	0.50
SC200	0.04	0.04	0.04
SC201	0.37	0.14	0.14
SC202	4.45	3.22	4.66
SC203	0.52	0.15	0.30
SC205	0.02	0.00	0.01
SC206	0.09	0.01	0.12

APPENDIX 19: LIMITING ANALYTES REQUIRING >1 HA AREA FOR LAND APPLICATION OF DRILLING WASTE SOLIDS (SCENARIO 4)

Limiting Analytes Requiring >1 ha Area for Land Application of Drilling Waste Solids (Scenario 4).

Sump Number	Solid Vol, m3	Calc Wet BD g/cm3	EC	SAR	Cl	Na	Oil 10000	Oil 20000	Cu	Zn	V	Cr	Ni	Cd	Pb
										(ha)					
SC3	N/A	0.622													
SC4	N/A	1.590													
SC5	N/A	1.880													
SC6	N/A	1.650													
SC7	N/A	0.283													
SC8	N/A	1.620													
SC9A	430.0	0.199													
SC9BD	166.0	0.319													
SC9C	189.0	1.250	3.07		3.01		2.03	1.02							
SC10	612.0	0.728		1.09		1.38					1.07				
SC11	157.0	0.431													
SC12	53.5	0.787													
SC13	110.0	0.408		1.25											
SC14A	46.0	1.300													
SC14B	100.0	1.030													
SC15	183.0	0.738													
SC16	135.0	0.645													
SC17	120.0	0.589													
SC18	205.0	0.452													
SC19B	880.0	1.210	5.45	1.48	4.89	3.16	1.10				2.23		1.78		
SC19C	402.0	1.350	1.77		1.16						1.05				
SC21	590.0	0.695				1.36					1.32				
SC22	N/A	0.463													
SC23	N/A	0.507													
SC24	1148.2	0.486	1.01			1.44					1.56		1.13		
SC25	373.0	0.606													
SC26	672.0	0.610									1.16				
SC27	288.0	0.712													
SC28	571.0	0.594	1.08		2.86	1.53									
SC29	600.0	0.510	5.63	2.17	8.56	11.40									
SC30A	2.4	0.640													
SC32	561.0	0.745													
SC33	225.0	0.289													
SC34	1750.0	0.322		1.73		2.09					1.28				
SC35	3643.0	0.495	3.91	4.82		8.00					3.70	2.14	2.19	1.04	1.44
SC36	501.0	0.693	5.24		5.84	1.09					1.00				
SC37	383.0	0.621													
SC38	278.0	1.240													
SC39	639.0	0.426													
SC40	1639.0	0.379	2.33	2.49	1.32	6.52					1.46				
SC41	681.0	0.198				1.36									
SC42	133.0	0.890													
SC43	382.0	0.743													
SC44	146.0	0.786													
SC45	768.0	0.654	1.32			1.49					1.27				
SC46	781.0	0.377	1.11		1.12	1.28									
SC47	553.0	0.650				1.86					1.25				

N/A = Data Not Available; Areas could not be calculated where volume data not available.

(Continued). Limiting Analytes Requiring >1 ha Area for Land Application of Drilling Waste Solids (Scenario 4).

Sump Number	Solid Vol, m3	Calc Wet BD g/cm3	EC	SAR	Cl	Na	Oil 10000	Oil 20000	Cu	Zn	V	Cr	Ni	Cd	Pb
			(ha)												
SC48	551.0	0.423													
SC49	1107.0	0.746	2.23	2.41		3.73					1.18		1.24		
SC50	828.0	0.476				1.09					1.21				
SC51	N/A	0.769													
SC52A	N/A	1.030													
SC52C	N/A	0.619													
SC53	230.0	0.701	1.10		1.07										
SC54	477.0	0.888				1.02					1.51				
SC55	577.0	0.900				1.38					1.21				
SC56A	88.0	0.261	1.03		2.00										
SC56B	315.0	0.490	4.57	1.27	6.94	1.88									
SC56C	17.0	0.361													
SC57	423.0	1.330	6.94		8.66	2.55	4.44	2.22							
SC58	401.0	0.587	2.62		2.79										
SC59	346.0	0.674	1.88		1.91										
SC60	320.0	0.788		1.55											
SC61	755.0	1.510	7.66		7.18	2.96	3.26	1.63			1.39		1.50		1.03
SC62AB	279.0	1.510	4.42		4.99	1.55	2.74	1.37			1.06				
SC62CD	256.0	0.737					2.23	1.11							
SC63	117.0	0.547													
SC64	114.0	0.545													
SC65	42.0	0.433													
SC66	22.0	0.680													
SC67	52.0	0.898													
SC68	77.0	1.030													
SC69	402.0	0.492	1.06		1.42		1.41								
SC70	136.0	0.312													
SC71A	143.0	1.480	2.77		1.89										
SC71BC	95.0	0.355													
SC72A	73.0	0.367													
SC72BC	160.0	1.630	3.76		5.22	1.05	1.04								
SC73	422.0	0.754									1.01				1.99
SC74	229.0	0.602				1.13									
SC75	66.0	1.260													
SC76	240.0	0.722													
SC77	582.0	0.605													
SC78	207.0	0.588	3.13		4.85	1.38									
SC79	340.0	1.020													
SC80	1622.0	0.454	2.58	2.94		5.83					2.08		1.71		
SC81ABCD	1117.0	0.675	2.94		3.09	1.36	8.83	4.41			1.35		1.21		1.51
SC82	896.0	0.351		1.51		1.08									
SC83	287.0	0.397													
SC84	261.0	0.629													
SC85	78.0	0.526													
SC86	112.0	0.785													
SC87	168.0	0.394													

N/A = Data Not Available; Areas could not be calculated where volume data not available.

(Concluded). Limiting Analytes Requiring >1 ha Area for Land Application of Drilling Waste Solids (Scenario 4).

Sump Number	Solid Vol, m3	Calc Wet BD g/cm3	EC	SAR	Cl	Na	Oil 10000	Oil 20000	Cu	Zn	V	Cr	Ni	Cd	Pb
			(ha)												
SC88	275.0	0.308													
SC89	60.0	0.711													
SC90	41.0	0.762													
SC91	487.0	0.585				1.16					1.01				
SC92	96.0	1.220													
SC93	501.0	0.823	2.88	2.61	2.55	3.08									
SC94	226.0	0.660													
SC95	2259.0	0.486	2.39	5.84		6.23				3.76	2.22	1.04	3.15		
SC96	N/A	1.910													
SC97	349.0	0.624													
SC98	735.0	0.710	8.77		29.80	5.00					1.21		1.49		
SC99	340.0	0.449	1.51		2.06		1.27								
SC100	134.0	0.776													
SC101	188.0	0.711													
SC102	87.0	0.529	1.11		1.57										
SC103	189.0	0.822													
SC104	314.0	0.463													
SC105	308.0	0.612	2.08		2.31										
SC106	285.0	0.375	1.25		1.80	1.13									
SC107	780.0	0.943	10		11.70					1.51	1.46		1.11		
SC108	1554.0	0.646	5.38	1.24	6.49	3.40	6.27	3.13		4.57					
SC200	216.0	0.109													
SC201	287.0	0.654													
SC202	10395.0	0.339	11	11	1.68	29.90	8.64	4.32	1.37	32.30	3.79	2.28	4.45	3.22	4.66
SC203	1234.0	0.295				1.94									
SC205	16.0	0.854													
SC206	214.0	0.443	3.58	8.28	13.00	11.80									

N/A = Data Not Available; Areas could not be calculated where volume data not available.

APPENDIX 20: THICKNESS OF THE DRILLING WASTE SOLIDS LAYER APPLIED TO LAND (SCENARIO 4)

Thickness of the Drilling Waste Solids Layer Applied to Land (Scenario 4).

Sump Number	Solid Vol, m3	Calc Wet BD g/cm3	EC	SAR	Cl	Na	NO3-N & NH4-N	B	Oil 10000	Oil 20000	Cu	Zn
								(cm)				
SC3	N/A	0.622	10.600	14.700	371.000	10.300	4100.00	1040.0	321.000	643.00	137.0	4.91
SC4	N/A	1.590	1.840	5.460	3.340	5.880	10600.00	1650.0	41.800	83.60	61.4	4.11
SC5	N/A	1.880	0.898	1.160	5.190	3.030	89000.00	748.0	29.600	59.10	95.0	3.39
SC6	N/A	1.650	0.502	10.200	0.446	1.860	264.00	278.0	0.767	1.53	35.4	9.52
SC7	N/A	0.283	65.100	21.200	45.700	21.700	101000.00	2970.0	95.600	191.00	221.0	127.00
SC8	N/A	1.620	4.430	2.050	164.000	3.720	11300.00	410.0	47.400	94.90	28.2	14.10
SC9A	430.0	0.199	12.900	35.100	7.940	7.160	19400.00	1400.0	6.090	12.20	233.0	6.90
SC9BD	166.0	0.319	3.840	19.100	2.730	4.600	13000.00	5100.0	4.220	8.45	142.0	2.22
SC9C	189.0	1.250	0.616	11.500	0.628	2.340	867.00	491.0	0.930	1.86	38.9	14.80
SC10	612.0	0.728	6.200	5.590	150.000	4.450	8060.00	855.0	80.800	162.00	63.4	38.50
SC11	157.0	0.431	15.100	10.400	47.900	7.230	1510.00	187.0	129.000	258.00	82.3	58.70
SC12	53.5	0.787	1.020	14.300	0.959	5.420	3360.00	226.0	254.000	508.00	56.7	40.30
SC13	110.0	0.408	2.270	0.878	2.130	2.150	168.00	405.0	272.000	545.00	78.7	62.00
SC14A	46.0	1.300	6.560	5.380	15.500	5.460	2710.00	390.0	95.900	192.00	107.0	14.20
SC14B	100.0	1.030	12.300	8.660	42.200	7.330	6970.00	1040.0	64.700	129.00	98.2	24.80
SC15	183.0	0.738	7.910	7.800	127.000	5.690	5850.00	438.0	226.000	452.00	100.0	40.60
SC16	135.0	0.645	8.670	5.090	63.300	3.420	7940.00	105.0	103.000	207.00	79.5	33.60
SC17	120.0	0.589	8.190	8.890	29.100	4.570	9580.00	133.0	94.300	189.00	70.9	36.30
SC18	205.0	0.452	10.700	13.400	10.300	6.550	7220.00	857.0	111.000	221.00	176.0	56.20
SC19B	880.0	1.210	1.610	5.960	1.800	2.780	8760.00	5670.0	7.970	15.90	39.9	19.30
SC19C	402.0	1.350	2.270	7.160	3.480	4.850	17100.00	2470.0	6.440	12.90	27.6	13.10
SC21	590.0	0.695	6.220	8.570	11.400	4.320	3400.00	90.3	62.600	125.00	95.9	34.80
SC22	N/A	0.463	10.600	9.820	8.500	3.560	921.00	60.7	23.000	46.00	134.0	58.90
SC23	N/A	0.507	9.510	3.160	10.700	3.100	56300.00	44.4	21.200	42.40	104.0	51.60
SC24	1148.2	0.486	11.300	14.400	90.400	8.000	6530.00	652.0	137.000	274.00	119.0	38.00
SC25	373.0	0.606	7.780	6.400	29.000	4.240	3920.00	232.0	165.000	330.00	122.0	48.00
SC26	672.0	0.610	9.870	18.300	33.900	9.260	155.00	287.0	126.000	252.00	104.0	43.90
SC27	288.0	0.712	8.680	16.100	75.000	9.660	15.10	263.0	93.600	187.00	92.9	41.90
SC28	571.0	0.594	5.290	9.600	2.000	3.720	4080.00	135.0	112.000	224.00	173.0	52.80
SC29	600.0	0.510	1.070	2.760	0.701	0.528	5850.00	392.0	67.600	135.00	121.0	65.60
SC30A	2.4	0.640	10.800	25.600	37.000	11.800	4780.00	243.0	67.900	136.00	93.9	28.00
SC32	561.0	0.745	8.690	15.500	25.700	8.350	8330.00	174.0	46.300	92.60	104.0	46.10
SC33	225.0	0.289	17.400	16.800	67.000	7.760	57100.00	260.0	433.000	866.00	276.0	46.30
SC34	1750.0	0.322	21.000	10.100	112.000	8.390	18100.00	518.0	388.000	777.00	169.0	82.60
SC35	3643.0	0.495	9.330	7.560	63.500	4.550	15400.00	684.0	253.000	505.00	107.0	53.40
SC36	501.0	0.693	0.957	12.200	0.859	4.610	3680.00	2840.0	144.000	289.00	77.6	34.60
SC37	383.0	0.621	16.300	6.190	90.700	9.750	23400.00	489.0	230.000	460.00	106.0	41.00
SC38	278.0	1.240	6.820	4.240	73.600	6.350	5860.00	406.0	161.000	323.00	61.0	22.10
SC39	639.0	0.426	12.100	18.300	28.000	8.760	7000.00	1010.0	469.000	939.00	144.0	61.60
SC40	1639.0	0.379	7.020	6.590	12.400	2.510	8100.00	453.0	82.600	165.00	161.0	16.60
SC41	681.0	0.198	12.200	13.200	16.200	5.010	18500.00	1120.0	13.000	26.00	300.0	56.10
SC42	133.0	0.890	4.920	8.090	34.400	5.720	3790.00	344.0	161.000	321.00	51.9	24.40
SC43	382.0	0.743	5.740	7.000	20.300	3.830	13900.00	140.0	103.000	207.00	74.5	49.50
SC44	146.0	0.786	7.430	18.000	13.200	8.880	5380.00	143.0	127.000	254.00	70.5	51.60
SC45	768.0	0.654	5.810	10.400	10.000	5.150	5580.00	376.0	510.000	1020.00	102.0	37.80
SC46	781.0	0.377	7.020	17.000	6.980	6.080	5340.00	1100.0	177.000	354.00	126.0	56.10
SC47	553.0	0.650	5.530	6.830	23.000	2.970	1020.00	372.0	140.000	280.00	71.9	30.20

N/A = Data Not Available.

(Continued). Thickness of the Drilling Waste Solids Layer Applied to Land (Scenario 4).

Sump Number	V	Cr	Ni	Cd	Pb
			(cm)		
SC3	9.92	21.10	11.30	63.90	26.00
SC4	5.42	12.10	5.13	76.10	6.38
SC5	19.70	37.40	16.60	28.40	11.60
SC6	2.70	9.80	4.24	13.10	11.00
SC7	19.00	40.80	18.20	103.00	73.40
SC8	2.14	6.17	3.08	7.58	11.40
SC9A	26.30	72.80	37.20	231.00	24.10
SC9BD	40.90	80.10	30.30	73.60	27.10
SC9C	3.55	11.20	6.37	41.00	8.25
SC10	5.72	16.20	7.80	32.90	9.42
SC11	6.72	23.70	8.94	47.40	16.10
SC12	6.16	16.10	6.25	42.00	39.40
SC13	4.27	8.55	10.90	128.00	30.60
SC14A	3.67	9.97	6.60	25.10	16.50
SC14B	4.53	13.60	6.81	20.90	39.60
SC15	5.87	20.70	9.13	31.30	26.50
SC16	4.78	16.40	8.76	103.00	25.60
SC17	5.52	18.60	8.11	40.50	27.70
SC18	9.08	25.00	16.50	20.80	18.60
SC19B	3.95	9.85	4.93	31.30	10.60
SC19C	3.82	9.11	4.25	21.20	10.20
SC21	4.48	17.00	7.88	39.10	21.60
SC22	7.82	12.50	12.40	86.60	49.90
SC23	5.55	11.40	10.50	23.60	23.50
SC24	7.36	21.20	10.20	64.20	21.40
SC25	7.10	21.10	9.38	113.00	37.10
SC26	5.79	18.70	9.15	67.70	37.40
SC27	5.73	18.60	8.76	39.70	35.40
SC28	8.33	24.10	14.80	404.00	18.60
SC29	12.80	29.30	14.90	65.80	29.50
SC30A	7.04	22.00	9.40	52.40	17.20
SC32	7.24	23.00	9.49	116.00	86.10
SC33	11.60	28.20	25.00	23.80	89.30
SC34	13.70	32.60	22.10	193.00	51.80
SC35	9.85	17.00	16.60	35.10	25.20
SC36	5.00	14.60	7.81	53.90	38.60
SC37	5.71	17.50	10.00	20.10	26.30
SC38	3.71	10.60	5.48	8.38	13.50
SC39	7.86	23.50	13.70	72.30	89.60
SC40	11.20	19.00	16.40	152.00	72.90
SC41	37.90	110.00	33.50	1210.00	40.30
SC42	3.94	15.30	4.80	19.10	19.30
SC43	5.55	17.30	6.39	135.00	40.10
SC44	5.51	23.50	6.73	305.00	57.40
SC45	6.05	11.50	8.42	37.10	30.40
SC46	8.15	24.80	10.80	49.40	63.80
SC47	4.44	13.70	6.86	107.00	16.70

(Continued). Thickness of the Drilling Waste Solids Layer Applied to Land (Scenario 4).

Sump Number	Solid Vol, m3	Calc Wet BD g/cm3	EC	SAR	Cl	Na	NO3-N & NH4-N	B	Oil 10000	Oil 20000	Cu	Zn
							(cm)					
SC48	551.0	0.423	19.400	28.100	60.200	16.300	8330.00	2250.0	56.200	112.00	104.0	54.30
SC49	1107.0	0.746	4.950	4.590	20.200	2.970	6300.00	269.0	78.900	158.00	75.7	56.40
SC50	828.0	0.476	11.000	15.300	50.100	7.630	8460.00	651.0	175.000	350.00	83.0	52.80
SC51	N/A	0.769	5.570	7.200	129.000	4.250	6.05	313.0	186.000	372.00	81.0	30.30
SC52A	N/A	1.030	0.376	0.279	0.170	0.163	2620.00	476.0	26.200	52.30	246.0	72.20
SC52C	N/A	0.619	11.400	16.600	70.500	9.150	2780.00	452.0	538.000	1080.00	124.0	45.70
SC53	230.0	0.701	2.090	17.400	2.140	7.830	8920.00	560.0	79.200	158.00	104.0	37.00
SC54	477.0	0.888	7.000	7.620	83.200	4.680	3080.00	184.0	75.100	150.00	61.4	27.90
SC55	577.0	0.900	6.570	6.810	107.000	4.170	2630.00	496.0	92.600	185.00	84.9	18.90
SC56A	88.0	0.261	0.855	1.770	0.440	1.200	9950.00	5540.0	45.000	90.00	217.0	39.70
SC56B	315.0	0.490	0.689	2.480	0.454	1.680	5620.00	14800.0	47.500	94.90	130.0	31.30
SC56C	17.0	0.361	1.000	6.880	0.520	1.480	2980.00	15200.0	15.300	30.60	185.0	37.80
SC57	423.0	1.330	0.610	11.400	0.488	1.660	609.00	760.0	0.953	1.91	24.1	12.10
SC58	401.0	0.587	1.530	9.090	1.440	4.300	6800.00	2150.0	51.600	103.00	125.0	27.30
SC59	346.0	0.674	1.840	10.200	1.820	5.640	4090.00	6050.0	297.000	593.00	79.2	41.00
SC60	320.0	0.788	4.400	2.070	9.050	10.000	3660.00	2260.0	84.700	169.00	57.7	20.10
SC61	755.0	1.510	0.985	8.410	1.050	2.550	2530.00	122.0	2.320	4.63	28.2	16.60
SC62AB	279.0	1.510	0.631	7.980	0.559	1.800	1500.00	57.2	1.020	2.04	31.9	8.65
SC62CD	256.0	0.737	3.240	7.090	3.450	3.690	124000.00	398.0	1.150	2.30	73.3	22.70
SC63	117.0	0.547	9.340	9.650	36.000	6.240	5030.00	443.0	152.000	305.00	69.9	52.70
SC64	114.0	0.545	6.530	7.180	29.200	3.450	5190.00	517.0	153.000	306.00	107.0	50.90
SC65	42.0	0.433	9.910	9.350	32.600	4.240	5470.00	111.0	115.000	231.00	158.0	53.80
SC66	22.0	0.680	7.360	11.900	12.900	5.820	7370.00	156.0	210.000	420.00	92.1	33.20
SC67	52.0	0.898	5.840	7.780	35.600	5.160	4760.00	113.0	139.000	278.00	47.9	30.70
SC68	77.0	1.030	5.420	12.400	20.700	8.420	4440.00	452.0	81.200	162.00	106.0	22.60
SC69	402.0	0.492	3.780	31.900	2.830	5.240	5010.00	170.0	2.850	5.69	115.0	30.50
SC70	136.0	0.312	39.100	11.400	47.100	16.900	9650.00	1200.0	100.000	200.00	259.0	69.00
SC71A	143.0	1.480	0.516	23.400	0.756	4.210	1290.00	416.0	1.550	3.10	30.9	6.73
SC71BC	95.0	0.355	40.400	9.860	41.500	16.500	6910.00	1020.0	44.700	89.30	198.0	48.30
SC72A	73.0	0.367	28.700	7.600	62.400	12.400	3670.00	745.0	227.000	455.00	143.0	41.10
SC72BC	160.0	1.630	0.425	13.600	0.306	1.520	488.00	205.0	1.540	3.08	12.7	12.30
SC73	422.0	0.754	7.210	8.280	252.000	5.280	9.79	515.0	49.100	98.30	45.1	19.40
SC74	229.0	0.602	2.580	5.160	3.360	2.030	7740.00	426.0	207.000	415.00	72.1	33.80
SC75	66.0	1.260	6.150	13.100	62.500	8.310	6190.00	223.0	6.520	13.00	37.8	20.00
SC76	240.0	0.722	7.610	9.640	101.000	6.780	17.40	297.0	51.300	103.00	66.0	22.80
SC77	582.0	0.605	11.400	15.700	72.700	8.960	3880.00	687.0	103.000	207.00	93.7	28.70
SC78	207.0	0.588	0.662	3.200	0.427	1.500	5410.00	733.0	58.600	117.00	77.0	18.90
SC79	340.0	1.020	4.020	4.930	37.800	3.740	6530.00	561.0	4.210	8.43	55.9	4.38
SC80	1622.0	0.454	6.280	5.530	46.300	2.780	12400.00	797.0	51.200	102.00	90.9	56.30
SC81ABCD	1117.0	0.675	3.800	27.300	3.620	8.210	8350.00	489.0	1.270	2.53	84.2	34.20
SC82	896.0	0.351	30.400	5.930	93.000	8.270	15200.00	450.0	71.300	143.00	92.3	77.20
SC83	287.0	0.397	17.100	18.500	79.800	8.920	4980.00	1970.0	114.000	229.00	117.0	65.90
SC84	261.0	0.629	12.200	13.200	49.800	8.880	52.10	389.0	106.000	212.00	111.0	39.50
SC85	78.0	0.526	9.680	8.990	16.800	5.430	10200.00	293.0	86.500	173.00	106.0	46.60
SC86	112.0	0.785	9.540	7.490	34.500	6.860	7780.00	448.0	159.000	319.00	57.6	30.70
SC87	168.0	0.394	13.000	8.150	29.300	5.150	29.50	215.0	254.000	508.00	125.0	36.50
SC88	275.0	0.308	12.200	11.300	8.930	5.020	4340.00	102.0	22.600	45.10	112.0	69.60

(Continued). Thickness of the Drilling Waste Solids Layer Applied to Land (Scenario 4).

Sump Number	V	Cr	Ni	Cd	Pb
			(cm)		
SC48	9.01	24.10	10.50	179.00	29.10
SC49	9.40	26.00	8.89	102.00	36.00
SC50	6.86	17.70	9.15	96.10	45.80
SC51	3.35	12.30	7.47	122.00	34.20
SC52A	12.60	22.30	12.90	232.00	35.20
SC52C	5.81	19.70	11.00	387.00	47.50
SC53	4.51	17.30	11.00	22.70	38.40
SC54	3.17	12.10	7.83	32.00	25.50
SC55	4.78	14.60	9.49	154.00	18.70
SC56A	18.20	26.30	42.60	918.00	59.70
SC56B	7.92	23.10	16.20	72.20	39.40
SC56C	11.00	25.90	32.70	35.20	61.10
SC57	4.50	10.50	4.36	21.80	4.81
SC58	6.90	20.90	14.40	143.00	40.10
SC59	5.41	16.00	8.45	53.50	26.90
SC60	4.88	13.40	5.89	36.60	42.70
SC61	5.42	15.10	5.03	17.80	7.32
SC62AB	2.63	8.55	3.61	35.60	11.30
SC62CD	10.40	32.30	11.80	47.60	6.70
SC63	7.42	24.50	9.72	439.00	43.50
SC64	7.45	17.90	10.50	34.50	28.90
SC65	5.15	22.20	10.90	34.10	49.80
SC66	3.93	15.80	8.06	49.00	24.90
SC67	4.59	14.70	7.06	72.80	19.50
SC68	6.76	18.50	8.85	38.80	22.80
SC69	13.20	29.40	13.70	56.40	17.60
SC70	18.60	45.90	25.60	75.50	27.80
SC71A	3.41	8.47	3.97	54.50	22.90
SC71BC	13.50	36.90	18.00	51.90	18.10
SC72A	15.40	32.10	13.80	41.00	14.60
SC72BC	2.46	7.65	2.79	15.10	6.63
SC73	4.18	12.90	5.30	25.80	2.12
SC74	6.33	18.90	7.58	47.80	21.90
SC75	3.99	9.11	3.94	29.10	6.47
SC76	4.82	15.80	6.62	27.50	33.50
SC77	7.06	18.80	10.50	92.40	40.00
SC78	7.31	7.02	13.00	34.20	32.50
SC79	16.80	26.70	9.54	236.00	8.22
SC80	7.80	21.90	9.51	64.40	19.60
SC81ABCD	8.25	20.70	9.23	81.80	7.40
SC82	13.20	22.70	14.00	684.00	44.80
SC83	12.20	25.50	12.70	79.50	21.00
SC84	5.13	17.80	10.20	27.00	22.20
SC85	6.38	22.40	10.60	68.50	26.50
SC86	5.07	15.50	6.36	58.90	11.90
SC87	10.20	12.30	14.60	29.40	64.40
SC88	6.22	27.20	11.40	29.00	24.80

(Continued). Thickness of the Drilling Waste Solids Layer Applied to Land (Scenario 4).

Sump Number	Solid Vol, m3	Calc Wet BD g/cm3	EC	SAR	Cl	Na	NO3-N & NH4-N	B	Oil 10000	Oil 20000	Cu	Zn
			(cm)									
SC89	60.0	0.711	5.870	5.720	21.700	3.660	8910.00	216.0	234.000	469.00	44.1	5.88
SC90	41.0	0.762	6.620	5.880	16.600	4.130	5440.00	99.8	164.000	328.00	84.7	36.00
SC91	487.0	0.585	6.810	9.190	15.200	4.200	29.90	84.8	63.300	127.00	98.0	24.30
SC92	96.0	1.220	5.120	4.490	31.300	4.050	1320.00	80.1	103.000	206.00	73.7	13.00
SC93	501.0	0.823	1.740	1.920	1.970	1.630	2550.00	333.0	7.600	15.20	26.7	164.00
SC94	226.0	0.660	8.320	6.800	10.600	4.490	3770.00	217.0	190.000	379.00	96.6	51.60
SC95	2259.0	0.486	9.430	3.870	55.200	3.620	6150.00	1040.0	103.000	206.00	63.3	6.00
SC96	N/A	1.910	2.760	3.160	17.000	2.920	3020.00	248.0	52.500	105.00	20.9	9.02
SC97	349.0	0.624	7.730	8.160	54.700	6.760	3490.00	1680.0	72.800	146.00	52.0	33.90
SC98	735.0	0.710	0.838	8.020	0.247	1.470	1480.00	4930.0	108.000	217.00	44.7	50.00
SC99	340.0	0.449	2.250	32.800	1.650	4.970	2500.00	1120.0	2.680	5.37	78.9	41.30
SC100	134.0	0.776	4.120	7.900	4.650	4.320	4860.00	538.0	129.000	258.00	117.0	29.90
SC101	188.0	0.711	8.770	11.600	22.500	5.350	3500.00	379.0	281.000	563.00	58.7	29.00
SC102	87.0	0.529	0.787	7.040	0.552	3.880	464.00	14400.0	378.000	757.00	103.0	47.60
SC103	189.0	0.822	3.630	4.720	10.200	3.150	16100.00	251.0	101.000	203.00	77.6	12.00
SC104	314.0	0.463	9.330	13.300	29.600	6.730	26600.00	340.0	114.000	227.00	123.0	26.00
SC105	308.0	0.612	1.480	9.210	1.330	3.410	14200.00	6830.0	327.000	653.00	101.0	41.20
SC106	285.0	0.375	2.279	11.770	1.580	3.280	28100.00	5330.0	381.000	762.00	155.0	63.90
SC107	780.0	0.943	0.752	27.500	0.669	23.500	4390.00	9450.0	12.500	25.00	59.0	5.16
SC108	1554.0	0.646	2.890	12.600	2.390	4.570	8750.00	93.5	2.480	4.96	45.9	3.40
SC200	216.0	0.109	25.000	24.300	131.000	7.470	257000.00	1320.0	48.100	96.30	254.0	11.00
SC201	287.0	0.654	7.050	9.900	8.220	6.160	7960.00	851.0	24.700	49.30	80.0	30.20
SC202	10395.0	0.339	9.150	9.290	61.900	3.480	90800.00	1140.0	12.000	24.10	75.7	3.22
SC203	1234.0	0.295	15.700	16.000	32.000	6.350	50500.00	1860.0	678.000	1360.00	239.0	84.00
SC205	16.0	0.854	1.810	14.100	1.600	6.930	2450.00	363.0	117.000	234.00	70.5	27.50
SC206	214.0	0.443	0.598	0.259	0.165	0.181	3220.00	5400.0	32.200	64.50	149.0	52.40

N/A = Data Not Available.

(Concluded). Thickness of the Drilling Waste Solids Layer Applied to Land (Scenario 4).

Sump Number	V	Cr	Ni	Cd	Pb
			(cm)		
SC89	5.21	16.90	5.09	18.00	16.00
SC90	5.50	17.40	8.36	41.30	6.96
SC91	4.84	19.40	10.00	22.40	43.40
SC92	4.02	12.30	6.38	16.10	41.00
SC93	42.00	35.90	38.00	292.00	103.00
SC94	7.25	23.30	10.50	21.40	64.20
SC95	10.20	21.80	7.17	53.20	26.20
SC96	2.62	7.21	2.30	126.00	6.48
SC97	5.40	15.60	6.02	43.80	27.40
SC98	6.06	15.30	4.95	33.20	17.20
SC99	10.30	29.80	9.33	126.00	28.90
SC100	5.08	16.20	9.63	186.00	16.30
SC101	4.34	14.50	6.11	15.40	19.50
SC102	8.98	23.90	12.50	454.00	26.80
SC103	3.73	13.40	7.08	35.40	31.50
SC104	7.56	23.80	12.00	41.80	20.00
SC105	6.39	16.00	4.20	17.30	33.10
SC106	9.42	31.40	15.60	125.00	53.30
SC107	5.33	16.80	7.01	18.90	15.70
SC108	17.00	39.10	16.10	34.70	31.20
SC200	59.00	103.00	55.20	50.20	52.30
SC201	4.67	16.20	7.72	21.00	20.30
SC202	27.40	45.60	23.40	32.30	22.30
SC203	36.20	81.70	23.90	81.10	41.10
SC205	6.07	17.10	6.92	57.80	21.60
SC206	20.40	7.77	23.30	173.00	18.50

APPENDIX 21: MEAN VALUES FOR SELECTED PROPERTIES OF THE DRILLING WASTE LIQUIDS

Mean Values for Selected Properties of the Drilling Waste Liquids.

Sump	Liq Vol	pH	E.C.	SAR	Cl	Na	NH4&NO3	B	Oil	Cu	Zn	V	Cr
Number	m3		dS/m		mg/L				(mg/L)				
SC1	N/A	8.26	1.213	28.6	75.60	767.00	0.07	0.238	<0.1	<0.010	0.739	<0.030	<0.020
SC2	N/A	10.23	0.902	34.8	78.20	579.33	2.59	0.175	<0.1	<0.010	0.079	0.042	<0.020
SC4	N/A	8.80	10.565	69.2	8905.00	3530.00	0.04	0.278	<0.1	<0.010	<0.020	<0.030	0.685
SC5	N/A	8.67	7.800	60.6	6220.00	2410.00	0.02	0.139	<0.1	<0.010	<0.020	<0.030	<0.020
SC6	N/A	7.52	1.090	2.4	1030.00	171.00	0.03	<0.040	9610	<0.010	0.180	<0.030	<0.020
SC8	N/A	9.19	0.866	40.6	76.70	671.67	0.06	0.245	<0.1	0.020	0.101	<0.030	0.331
SC9A	45	7.91	8.300	2.0	115.00	59.50	0.00	0.112	354	0.059	0.041	0.048	0.024
SC9BD	192	9.54	4.818	5.1	912.75	398.50	1.18	0.168	54155	0.069	0.401	0.054	0.025
SC10	36	8.17	3.160	28.9	68.60	798.00	0.01	0.170	108	<0.010	0.080	0.071	<0.020
SC11	21	8.16	1.850	18.1	96.60	330.00	0.35	1.080	3.43	0.047	0.053	0.038	<0.020
SC12	24	9.60	22.300	15.9	8220.00	1470.00	13.05	<0.040	1.56	<0.010	<0.020	<0.030	0.408
SC13	148	11.50	4.367	49.9	332.37	906.67	16.41	1.174	8.57	0.036	0.487	0.214	0.128
SC15	278	9.71	1.670	37.7	52.77	422.00	1.50	0.842	2.00	<0.010	0.121	0.116	<0.020
SC16	75	9.24	1.535	34.9	58.30	392.50	0.82	1.090	2.50	<0.010	0.203	<0.030	<0.020
SC17	137	10.55	1.560	30.2	129.50	414.00	4.25	1.975	0.75	<0.010	0.221	0.242	<0.020
SC18	108	9.04	3.220	57.5	776.00	725.00	1.26	0.482	2.76	0.013	0.096	<0.030	0.943
SC19A	2351	8.22	15.100	24.2	4063.33	1310.00	0.73	0.187	0.44	0.011	0.071	<0.030	<0.020
SC21	N/A	8.19	4.460	66.9	3230.00	3470.00	0.01	3.390	<0.1	<0.010	0.361	<0.030	<0.020
SC22	N/A	10.21	0.726	34.3	355.00	540.33	0.04	0.797	<0.1	<0.010	<0.020	0.155	0.241
SC23	N/A	11.60	0.823	39.9	236.00	578.00	0.40	1.470	<0.1	<0.010	0.083	0.652	0.119
SC24	646	11.97	1.870	36.9	223.00	676.67	4.63	0.349	45.40	0.102	0.091	0.083	0.032
SC25	1310	9.18	0.721	35.2	136.10	531.33	0.06	0.325	1.44	<0.010	0.063	<0.030	<0.020
SC26	112	9.87	1.680	94.5	528.00	1320.00	49.20	0.735	16.70	0.030	0.150	<0.030	0.960
SC27	632	12.35	2.130	45.2	95.40	1260.00	76.45	0.317	25.40	0.063	0.137	0.059	1.251
SC28	268	8.75	4.055	30.4	674.50	1029.50	3.14	0.556	2.44	<0.010	0.197	<0.030	0.365
SC29	1147	8.38	21.270	24.6	8370.00	3792.67	1.53	0.656	2.22	<0.010	0.297	<0.030	<0.020
SC30A	538	8.92	1.567	2.6	99.00	149.33	0.03	0.059	2.89	<0.010	0.024	<0.030	<0.020
SC30B	338	6.78	26.150	39.3	8695.00	4500.00	0.06	0.573	1.33	0.041	0.361	<0.030	<0.020
SC31	357	9.50	13.420	25.9	4236.17	2626.63	2.58	0.183	2.95	<0.010	0.177	<0.030	0.032
SC32	1204	8.16	3.750	29.9	206.20	478.00	0.35	0.594	1.44	<0.010	0.085	<0.030	0.045
SC33	24	10.10	1.640	26.8	67.30	440.00	0.24	1.100	1.86	0.107	0.072	0.103	0.318
SC34	2773	8.73	6.133	19.4	29.73	277.67	2.43	0.206	0.89	0.010	0.064	0.051	0.200
SC35	1886	8.40	2.850	25.3	130.50	751.00	0.20	0.237	1.43	<0.010	0.092	0.042	0.308
SC36	227	8.52	37.550	27.5	12800.00	1505.00	1.82	0.122	1.78	<0.010	0.146	<0.030	<0.020
SC37	675	9.17	0.816	14.8	42.90	225.37	0.24	0.366	0.44	<0.010	0.033	0.054	<0.020
SC38	648	9.41	0.836	16.0	34.73	240.00	0.18	0.368	0.79	<0.010	0.045	0.082	0.022
SC39	483	8.31	5.033	36.9	177.00	1386.67	0.89	0.358	13.60	<0.010	0.143	<0.030	0.379
SC40	4146	8.42	3.307	26.2	188.00	871.00	0.04	0.144	2.33	<0.010	0.116	<0.030	0.083
SC41	817	8.64	3.353	31.7	305.00	970.67	3.13	0.307	2.44	0.016	0.161	0.032	<0.020
SC42	369	8.07	4.810	21.1	211.67	1085.00	2.14	0.409	1.33	0.013	0.116	<0.030	<0.020
SC43	513	10.27	4.567	34.6	537.33	1314.33	1.17	1.353	0.33	<0.010	0.156	0.135	<0.020
SC44	514	8.18	7.877	39.1	943.33	2100.00	1.76	1.630	446	<0.010	0.214	<0.030	<0.020
SC45	1562	8.86	4.550	39.2	276.67	1122.67	0.31	0.443	173	<0.010	0.137	<0.030	0.952
SC46	509	8.91	6.045	46.1	1055.00	1570.50	1.30	0.199	5800	0.023	0.169	<0.030	<0.020
SC47	368	8.48	2.297	21.4	52.53	522.67	184.81	0.190	7.33	<0.010	0.070	<0.030	0.335
SC48	1083	9.37	2.023	38.3	88.50	433.67	0.65	0.305	21.70	0.028	0.095	0.076	<0.020
SC49	469	9.11	4.617	40.5	490.83	1226.67	0.66	0.889	7.33	0.015	0.256	<0.030	<0.020

N/A = Data Not Available; SAR = Sodium Adsorption Ratio.

(Continued). Mean Values for Selected Properties of the Drilling Waste Liquids.

Sump Number	Ni	Cd mg/L	Pb
SC1	<0.030	<0.010	<0.100
SC2	<0.030	<0.010	<0.100
SC4	<0.030	<0.010	<0.100
SC5	<0.030	<0.010	<0.100
SC6	<0.030	<0.010	<0.100
SC8	<0.030	<0.010	<0.100
SC9A	0.059	0.013	0.169
SC9BD	0.073	0.011	0.166
SC10	<0.030	<0.010	<0.100
SC11	0.078	<0.010	0.128
SC12	<0.030	<0.010	<0.100
SC13	<0.030	<0.010	<0.100
SC15	<0.030	<0.010	<0.100
SC16	<0.030	<0.010	<0.100
SC17	<0.030	<0.010	<0.100
SC18	<0.030	<0.010	<0.100
SC19A	<0.030	<0.010	<0.100
SC21	<0.030	<0.010	<0.100
SC22	<0.030	<0.010	<0.100
SC23	<0.030	<0.010	<0.100
SC24	0.057	0.016	0.234
SC25	0.031	<0.010	<0.100
SC26	<0.030	<0.010	<0.100
SC27	<0.030	<0.010	<0.100
SC28	<0.030	<0.010	<0.100
SC29	<0.030	<0.010	<0.100
SC30A	<0.030	<0.010	<0.100
SC30B	0.032	<0.010	<0.100
SC31	<0.030	<0.010	<0.100
SC32	<0.030	<0.010	<0.100
SC33	<0.030	<0.010	<0.100
SC34	<0.030	<0.010	<0.100
SC35	<0.030	<0.010	<0.100
SC36	<0.030	<0.010	<0.100
SC37	<0.030	<0.010	<0.100
SC38	<0.030	<0.010	<0.100
SC39	<0.030	<0.010	<0.100
SC40	<0.030	<0.010	<0.100
SC41	<0.030	<0.010	<0.100
SC42	<0.030	<0.010	<0.100
SC43	<0.030	<0.010	<0.100
SC44	<0.030	<0.010	<0.100
SC45	<0.030	<0.010	<0.100
SC46	<0.030	<0.010	<0.100
SC47	<0.030	<0.010	<0.100
SC48	<0.030	<0.010	<0.100
SC49	<0.030	<0.010	<0.100

(Continued). Mean Values for Selected Properties of the Drilling Waste Liquids.

Sump Number	Liq Vol m3	pH	E.C. dS/m	SAR	Cl mg/L	Na	NH4&NO3	B	Oil	Cu	Zn	V	Cr
						--------	--------	--------	(mg/L)	--------	--------	--------	--------
SC50	882	8.47	6.847	45.7	148.00	1943.33	0.14	0.342	6.33	<0.010	0.224	0.037	0.905
SC51	N/A	8.53	0.509	22.6	18.50	335.00	160.00	0.139	0.75	<0.010	0.036	<0.030	<0.020
SC52A	N/A	7.97	17.260	112.2	41706.67	12140.00	0.41	<0.040	1.00	<0.010	0.622	<0.030	<0.020
SC52B	N/A	8.66	2.005	13.7	1145.00	1065.00	0.82	0.191	0.44	<0.010	0.059	<0.030	<0.020
SC52C	N/A	8.67	0.735	8.7	121.55	405.00	1.71	<0.040	2.33	<0.010	<0.020	<0.030	<0.020
SC53	500	8.37	5.260	7.3	1428.33	372.00	0.03	0.079	0.89	<0.010	0.033	<0.030	<0.020
SC54	339	8.64	3.980	12.9	123.00	543.50	0.04	0.518	0.59	0.052	0.072	<0.030	<0.020
SC55	303	8.84	2.695	40.4	56.90	732.50	4.42	0.166	0.69	<0.010	0.273	<0.030	0.547
SC56B	220	8.38	28.600	20.0	9150.00	1830.00	0.17	0.047	0.89	<0.010	0.194	<0.030	0.035
SC56A	27	8.08	54.800	38.5	19600.00	4640.00	0.17	0.370	1.58	<0.010	0.426	<0.030	0.454
SC56C	14	8.36	28.300	21.4	9180.00	1980.00	20.27	0.159	1.28	<0.010	0.203	<0.030	0.116
SC57	2	5.70	1.610	0.7	361.00	40.80	0.00	0.080	29.60	0.067	0.165	0.045	<0.020
SC58	210	8.78	24.850	43.1	8555.00	1485.00	1.05	0.286	2.22	<0.010	0.153	<0.030	0.022
SC59	959	8.29	5.360	9.5	1529.67	404.33	3.86	<0.040	3.00	<0.010	0.048	<0.030	0.181
SC60	694	9.70	6.473	35.8	467.00	513.33	0.64	0.093	1.07	0.012	0.108	<0.030	<0.020
SC61	975	11.00	12.900	51.0	759.50	1210.00	9.68	0.158	49.00	0.118	0.174	0.048	0.026
SC62AB	22	7.57	0.486	0.6	74.33	17.13	0.02	0.062	9251	0.021	0.058	<0.030	<0.020
SC62CD	683	7.75	3.774	8.4	733.17	502.80	1.66	0.181	2690	0.040	0.090	<0.030	<0.020
SC63	348	9.46	2.017	25.2	170.00	518.00	0.44	0.857	1.27	<0.010	0.281	0.124	0.029
SC64	260	8.41	9.387	24.6	590.33	2280.00	1.75	0.605	1.11	<0.010	0.241	<0.030	0.702
SC65	13	9.94	2.200	45.1	131.00	561.00	1.21	1.810	5.56	<0.010	0.059	0.158	<0.020
SC66	18	8.34	4.070	14.1	1180.00	766.00	0.26	1.360	1.50	<0.010	0.084	<0.030	<0.020
SC67	168	9.25	2.210	37.8	132.00	586.33	1.18	1.460	2.68	<0.010	0.088	0.098	<0.020
SC69	263	8.05	1.105	1.5	269.00	52.60	0.00	0.254	661	0.049	0.032	0.035	<0.020
SC70	156	8.67	0.695	4.6	47.07	94.23	0.04	0.091	17.70	0.048	0.051	0.062	<0.020
SC71BC	40	7.36	0.321	0.3	61.25	6.39	0.02	<0.040	580	0.028	0.028	<0.030	<0.020
SC72A	40	10.13	1.144	26.7	33.50	345.50	0.23	0.214	3.00	<0.010	0.280	0.102	<0.020
SC72BC	284	8.54	1.114	0.6	343.97	23.09	0.20	0.086	583	0.081	0.056	<0.030	<0.020
SC73	197	7.90	0.516	6.7	8.49	108.95	16.50	<0.040	0.67	<0.010	<0.020	<0.030	<0.020
SC74	403	8.38	10.000	24.9	1930.00	2030.00	0.03	0.382	1.00	<0.010	0.206	0.032	<0.020
SC75	77	7.56	1.810	4.8	122.00	260.00	0.03	0.116	0.78	<0.010	0.028	<0.030	<0.020
SC76	240	8.79	2.977	41.2	60.37	767.67	289.16	0.619	1.89	<0.010	0.091	<0.030	<0.020
SC77	854	7.84	0.458	3.7	7.84	76.53	0.09	<0.040	0.78	<0.010	<0.020	<0.030	<0.020
SC80	1774	9.01	4.257	72.2	115.93	1294.33	0.36	0.282	1.56	<0.010	0.138	0.059	0.431
SC81ABCD	1478	7.14	4.313	4.4	1333.17	318.17	0.08	0.082	4.38	0.052	0.061	<0.030	<0.020
SC82	2380	8.35	1.304	25.9	21.37	364.33	0.47	0.107	46.30	<0.010	0.079	<0.030	0.504
SC83	747	8.23	1.031	12.1	22.68	330.17	0.05	0.131	2.00	<0.010	0.038	<0.030	0.747
SC84	579	9.32	2.918	55.8	270.17	678.33	65.67	0.594	677	0.022	0.139	0.050	<0.020
SC85	451	9.34	2.723	28.6	598.33	559.33	0.82	0.964	1660	0.022	0.027	0.072	<0.020
SC86	369	9.65	1.203	16.9	114.23	326.00	0.83	0.533	1.00	0.014	0.115	0.089	<0.020
SC87	178	10.20	4.925	22.6	241.00	684.00	26.70	0.651	11.60	0.013	0.247	0.106	1.800
SC88	119	7.85	1.860	9.6	205.00	348.00	1.36	0.514	3.55	<0.010	0.065	0.112	<0.020
SC89	162	9.85	2.015	34.6	290.00	747.50	2.05	1.415	8.44	<0.010	0.704	0.225	<0.020
SC90	194	10.05	2.375	39.6	227.00	562.00	1.85	1.233	2.59	<0.010	0.065	0.192	<0.020
SC92	323	9.39	2.073	36.6	335.33	499.67	1.93	1.337	1.78	<0.010	0.094	0.068	<0.020
SC93	272	8.49	11.822	30.6	7768.00	2208.00	1.81	0.789	11652	0.021	0.156	<0.030	0.044
SC94	501	8.62	2.790	22.5	663.33	637.00	0.57	0.609	25.60	<0.010	0.118	<0.030	<0.020

N/A = Data Not Available; SAR = Sodium Adsorption Ratio.

(Continued). Mean Values for Selected Properties of the Drilling Waste Liquids.

Sump	Ni	Cd	Pb
Number		mg/L	
SC50	<0.030	<0.010	<0.100
SC51	<0.030	<0.010	<0.100
SC52A	<0.030	<0.010	<0.100
SC52B	<0.030	<0.010	<0.100
SC52C	<0.030	<0.010	<0.100
SC53	<0.030	<0.010	<0.100
SC54	0.067	<0.010	0.161
SC55	<0.030	<0.010	<0.100
SC56B	<0.030	<0.010	<0.100
SC56A	<0.030	<0.010	<0.100
SC56C	<0.030	<0.010	<0.100
SC57	0.113	0.015	0.214
SC58	<0.030	<0.010	<0.100
SC59	<0.030	<0.010	<0.100
SC60	0.044	<0.010	<0.100
SC61	0.063	0.014	0.192
SC62AB	0.032	<0.010	<0.100
SC62CD	0.052	<0.010	<0.100
SC63	0.033	<0.010	0.124
SC64	<0.030	<0.010	<0.100
SC65	<0.030	<0.010	<0.100
SC66	<0.030	<0.010	<0.100
SC67	0.056	<0.010	<0.100
SC69	0.052	0.012	0.142
SC70	0.049	0.010	0.144
SC71BC	0.034	<0.010	<0.100
SC72A	<0.030	<0.010	<0.100
SC72BC	0.067	<0.010	0.136
SC73	<0.030	<0.010	<0.100
SC74	<0.030	<0.010	<0.100
SC75	<0.030	<0.010	<0.100
SC76	<0.030	<0.010	<0.100
SC77	<0.030	<0.010	<0.100
SC80	<0.030	<0.010	<0.100
SC81ABCD	0.053	<0.010	0.133
SC82	<0.030	<0.010	<0.100
SC83	<0.030	<0.010	<0.100
SC84	<0.030	<0.010	<0.100
SC85	<0.030	<0.010	<0.100
SC86	0.061	<0.010	<0.100
SC87	0.030	<0.010	<0.100
SC88	<0.030	<0.010	<0.100
SC89	0.085	<0.010	<0.100
SC90	<0.030	<0.010	<0.100
SC92	<0.030	<0.010	<0.100
SC93	<0.030	<0.010	<0.100
SC94	<0.030	<0.010	<0.100

(Continued). Mean Values for Selected Properties of the Drilling Waste Liquids.

Sump Number	Liq Vol m3	pH	E.C. dS/m	SAR	Cl mg/L	Na	NH4&NO3	B	Oil	Cu	Zn	V	Cr
						(mg/L)							
SC95	806	8.75	2.490	60.5	66.35	688.50	0.65	0.249	8.44	0.010	0.147	<0.030	<0.020
SC96	222	8.67	4.710	28.0	689.00	1240.00	0.02	0.650	1.35	<0.010	0.161	<0.030	0.554
SC97	528	8.32	4.694	19.0	75.00	782.20	4.81	0.156	1.33	0.020	0.075	0.077	0.022
SC98	593	8.12	35.150	48.4	11070.00	1545.00	0.98	0.119	1.78	0.029	<0.020	<0.030	<0.020
SC99	209	9.38	2.710	6.4	707.50	326.50	0.68	0.283	7520	0.048	0.049	0.040	<0.020
SC100	555	8.64	2.847	41.9	143.00	654.33	0.32	0.430	26.10	0.012	0.046	<0.030	0.065
SC101	277	7.96	3.200	22.1	577.50	739.50	1.33	0.523	138	<0.010	0.053	<0.030	<0.020
SC102	60	8.46	34.700	10.5	12950.00	464.00	31.60	0.134	2.00	0.072	0.044	0.046	<0.020
SC103	105	8.19	3.283	26.0	132.67	804.00	0.71	0.799	2.22	<0.010	0.076	0.040	<0.020
SC104	195	10.01	5.995	40.1	365.00	829.50	2.74	1.090	1.78	0.059	0.200	0.133	<0.020
SC105	267	9.97	17.350	22.3	6115.00	1031.50	5.54	0.336	689	0.011	0.145	0.075	<0.020
SC106	298	11.33	25.700	22.9	8573.33	978.00	3.20	0.313	8.44	0.028	0.055	0.073	<0.020
SC107	470	9.08	12.297	60.9	1966.67	1960.00	17.44	0.408	26.33	<0.010	0.500	0.111	<0.020
SC108	1148	9.74	5.278	10.4	1420.50	747.50	2.76	0.761	30800	0.014	0.274	<0.030	<0.020
SC201	454	10.04	3.760	41.6	941.50	787.50	3.63	0.115	108	<0.010	<0.020	0.039	0.330
SC202	1815	7.74	3.037	12.8	37.67	627.33	0.06	0.090	191	<0.010	1.293	<0.030	<0.020
SC203	412	8.46	1.160	24.0	36.80	301.00	0.08	<0.040	2.09	<0.010	0.076	<0.030	<0.020
SC204	1822	8.58	3.990	42.1	211.33	970.33	2.05	0.143	7.88	<0.010	0.183	<0.030	<0.020
SC205	76	11.95	43.850	8.5	16550.00	989.50	11.48	<0.040	3.78	<0.010	<0.020	<0.030	<0.020
SC206	202	8.55	148.500	790.2	116500.00	77400.00	3.13	<0.040	2.11	<0.010	<0.020	<0.030	<0.020

SAR = Sodium Adsorption Ratio.

(Concluded). Mean Values for Selected Properties of the Drilling Waste Liquids.

Sump Number	Ni	Cd	Pb
		mg/L	
SC95	<0.030	<0.010	<0.100
SC96	<0.030	<0.010	<0.100
SC97	<0.030	<0.010	<0.100
SC98	<0.030	<0.010	<0.100
SC99	0.064	<0.010	0.128
SC100	<0.030	<0.010	<0.100
SC101	<0.030	<0.010	<0.100
SC102	0.068	0.016	0.202
SC103	<0.030	<0.010	<0.100
SC104	0.071	0.015	0.199
SC105	<0.030	<0.010	<0.100
SC106	<0.030	<0.010	<0.100
SC107	<0.030	<0.010	<0.100
SC108	<0.030	<0.010	<0.100
SC201	<0.030	<0.010	<0.100
SC202	<0.030	<0.010	<0.100
SC203	<0.030	<0.010	<0.100
SC204	<0.030	<0.010	<0.100
SC205	<0.030	<0.010	<0.100
SC206	<0.030	<0.010	<0.100

APPENDIX 22: APPLICATION RATES FOR THE LIQUID PHASE DRILLING WASTES

Application Rates for the Liquid Phase Drilling Wastes.

Sump Number	Liquid Vol, m3	EC	SAR	Cl	Na	NH4&NO3	B	Oil		Cu	Zn	Ni	Cr
								10000	20000				
								(m3/ha)					
SC1	N/A	4825	484	10600.0	652	5880000	42000	N/C	N/C	40000000	406000	3330000	10000000
SC2	N/A	8550	395	10200.0	863	155000	57000	N/C	N/C	40000000	3810000	1200000	10000000
SC4	N/A	342	196	89.8	142	1e+07	36000	N/C	N/C	40000000	30000000	3330000	146000
SC5	N/A	471	224	129.0	207	2e+07	71900	N/C	N/C	40000000	30000000	3330000	10000000
SC6	N/A	5831	9827	777.0	2920	1e+07	500000	1040	2080	40000000	1670000	3330000	10000000
SC8	N/A	9390	338	10400.0	744	6700000	40800	N/C	N/C	10000000	2980000	2310000	302000
SC9A	0.0	441	13347	6960.0	8400	1e+08	89300	28200	56500	3390000	7320000	1040000	4170000
SC9BD	45.0	797	3225	876.0	1250	338000	59500	185	369	2920000	748000	930000	4040000
SC10	36.0	1293	480	11700.0	627	3e+07	58800	92600	185000	40000000	3750000	704000	10000000
SC11	21.0	2548	782	8280.0	1520	1160000	9260	2920000	5830000	4260000	5660000	1320000	10000000
SC12	24.0	158	898	97.3	340	30700	500000	6410000	12800000	40000000	30000000	3330000	245000
SC13	148.0	890	274	2410.0	551	24400	8520	1170000	2330000	5560000	616000	234000	779000
SC15	278.0	2940	364	15200.0	1180	267000	11900	5000000	10000000	40000000	2480000	431000	10000000
SC16	75.0	3324	395	13700.0	1270	489000	9170	4000000	8000000	26700000	1480000	1820000	10000000
SC17	137.0	3245	458	6180.0	1210	94100	5060	13300000	26700000	22200000	1360000	207000	10000000
SC18	108.0	1265	237	1030.0	690	318000	20700	3620000	7250000	16000000	3130000	1960000	106000
SC19A	2351.0	236	577	197.0	382	547000	53400	22700000	45500000	17600000	4230000	3330000	10000000
SC21	N/A	869	203	248.0	144	6e+07	2950	N/C	N/C	40000000	831000	3330000	10000000
SC22	N/A	15244	402	2250.0	925	1e+07	12500	N/C	N/C	40000000	30000000	322000	416000
SC23	N/A	10650	344	3390.0	865	1000000	6800	N/C	N/C	40000000	3610000	76700	840000
SC24	645.8	2511	373	3590.0	739	86300	28700	220000	441000	1960000	3280000	600000	3160000
SC25	1310.0	15589	391	5880.0	941	6630000	30700	6940000	13900000	40000000	4790000	3330000	10000000
SC26	112.0	2915	143	1520.0	379	8130	13600	599000	1200000	6670000	2000000	3330000	104000
SC27	632.0	2110	303	8390.0	397	5230	31600	394000	787000	3170000	2200000	847000	79900
SC28	268.0	968	456	1190.0	486	127000	18000	4100000	8200000	21100000	1520000	3330000	274000
SC29	1147.0	166	568	95.6	132	262000	15300	4500000	9010000	40000000	1010000	3330000	5170000
SC30A	537.6	3225	8206	8080.0	3350	1e+07	169000	3460000	6920000	40000000	12700000	3330000	10000000
SC30B	338.0	134	350	92.0	111	6250000	17500	7520000	15000000	4940000	831000	3330000	10000000
SC31	357.0	266	538	189.0	190	155000	54500	3400000	6790000	40000000	1690000	3330000	3130000
SC32	1204.0	1058	463	3880.0	1050	1160000	16800	6940000	13900000	40000000	3530000	3330000	2220000
SC33	24.0	3018	518	11900.0	1140	1670000	9090	5380000	10800000	1870000	4170000	485000	314000
SC34	2773.0	611	729	26900.0	1800	165000	48500	11200000	22500000	19400000	4690000	974000	500000
SC35	1886.0	1464	550	6130.0	666	2050000	42300	6990000	14000000	40000000	3280000	1200000	325000
SC36	227.0	93	504	62.5	332	220000	82300	5620000	11200000	40000000	2050000	3330000	10000000
SC37	675.0	10886	968	18600.0	2220	1660000	27300	22700000	45500000	40000000	9000000	920000	6980000
SC38	648.0	10248	893	23000.0	2080	2220000	27200	12700000	25300000	40000000	6720000	607000	4480000
SC39	483.0	759	372	4520.0	361	447000	27900	735000	1470000	40000000	2100000	3330000	264000
SC40	4146.0	1226	530	4260.0	574	1e+07	69400	4290000	8580000	40000000	2590000	2380000	1200000
SC41	817.0	1206	436	2620.0	515	128000	32600	4100000	8200000	12200000	1860000	1560000	10000000
SC42	369.0	798	665	3780.0	461	187000	24400	7520000	15000000	15800000	2590000	2000000	10000000
SC43	513.0	846	398	1490.0	380	342000	7390	30300000	60600000	40000000	1920000	371000	10000000
SC44	514.0	466	351	848.0	238	228000	6130	22400	44800	40000000	1400000	2000000	10000000
SC45	1562.0	849	350	2890.0	445	1270000	22600	57800	116000	30000000	2200000	1810000	105000
SC46	509.0	620	296	758.0	318	307000	50300	1720	3450	8890000	1780000	1790000	5130000
SC47	368.0	1915	655	15200.0	957	2160	52600	1360000	2730000	40000000	4270000	3330000	298000
SC48	1083.0	2258	359	9040.0	1150	619000	32800	461000	922000	7060000	3150000	661000	10000000

N/A = Data Not Available; N/C = Not calculated due to mean concentration below detection limit.

(Continued). Application Rates for the Liquid Phase Drilling Wastes.

Sump Number	Ni	Cd	Pb
	--------	(m3/ha)	-------
SC1	1670000	300000	2000000
SC2	1670000	300000	2000000
SC4	1670000	300000	2000000
SC5	1670000	300000	2000000
SC6	1670000	300000	2000000
SC8	1670000	300000	2000000
SC9A	424000	115000	592000
SC9BD	341000	136000	602000
SC10	1670000	300000	2000000
SC11	321000	300000	781000
SC12	1670000	300000	2000000
SC13	893000	300000	2000000
SC15	1670000	300000	2000000
SC16	1670000	300000	2000000
SC17	1670000	300000	2000000
SC18	1670000	300000	1300000
SC19A	1190000	300000	2000000
SC21	1670000	300000	2000000
SC22	1670000	300000	2000000
SC23	1670000	300000	2000000
SC24	441000	95700	427000
SC25	798000	300000	2000000
SC26	1670000	300000	2000000
SC27	1670000	300000	2000000
SC28	1670000	300000	2000000
SC29	1670000	300000	2000000
SC30A	1670000	300000	2000000
SC30B	794000	300000	1260000
SC31	1670000	300000	2000000
SC32	1090000	300000	2000000
SC33	1670000	300000	2000000
SC34	1670000	300000	2000000
SC35	1670000	300000	2000000
SC36	1670000	300000	2000000
SC37	1670000	300000	2000000
SC38	1670000	300000	1230000
SC39	1670000	300000	2000000
SC40	1670000	300000	2000000
SC41	1140000	300000	1400000
SC42	1670000	300000	2000000
SC43	1670000	300000	2000000
SC44	1670000	300000	2000000
SC45	1670000	300000	2000000
SC46	862000	300000	1230000
SC47	1670000	300000	2000000
SC48	1000000	300000	1230000

(Continued). Application Rates for the Liquid Phase Drilling Wastes.

Sump Number	Liquid Vol, m3	EC	SAR	Cl	Na	NH4&NO3	B	Oil		Cu	Zn	Ni	Cr
								10000	20000				
								(m3/ha)					
SC49	469.0	836	339	1630.0	408	604000	11300	1360000	2730000	13300000	1170000	3330000	10000000
SC50	882.0	542	300	5410.0	257	2910000	29200	1580000	3160000	40000000	1340000	1360000	110000
SC51	N/A	4e+05	619	43200.0	1490	2500	71900	13300000	26700000	40000000	8330000	3330000	10000000
SC52A	N/A	205	120	19.2	41	965000	341000	10000000	20000000	40000000	483000	3330000	10000000
SC52B	N/A	2286	1051	699.0	469	491000	52400	22700000	45500000	40000000	5080000	3330000	10000000
SC52C	N/A	14670	1727	6580.0	1230	235000	500000	4290000	8580000	40000000	30000000	3330000	10000000
SC53	500.0	723	2108	560.0	1340	2e+07	127000	11200000	22500000	40000000	9180000	3330000	10000000
SC54	339.0	989	1127	6500.0	920	1e+07	19300	16900000	33900000	3880000	4170000	3330000	6060000
SC55	303.0	1567	340	14100.0	683	90600	60400	14500000	29000000	25000000	1100000	3330000	183000
SC56A	220.0	63	357	40.8	108	2350000	27000	6330000	12700000	40000000	704000	3330000	220000
SC56B	27.0	122	703	87.4	273	2350000	213000	11200000	22500000	40000000	1550000	3330000	2860000
SC56C	14.0	124	656	87.1	253	19700	62900	7810000	15600000	40000000	1480000	3330000	862000
SC57	2.0	3099	0	2220.0	12300	2e+07	125000	338000	676000	2990000	1820000	1110000	10000000
SC58	210.0	141	318	93.5	337	381000	35000	4500000	9010000	40000000	1970000	3330000	4650000
SC59	959.0	708	1570	523.0	1240	104000	370000	3330000	6670000	40000000	6210000	3330000	554000
SC60	694.0	576	385	1710.0	974	625000	107000	9350000	18700000	16700000	2790000	3330000	10000000
SC61	975.0	277	267	1050.0	413	41300	63300	204000	408000	1690000	1720000	1050000	3850000
SC62AB	22.0	0	0	10800.0	29200	2e+07	160000	1080	2160	9520000	5140000	2380000	7320000
SC62CD	683.0	1051	1816	1090.0	994	241000	55100	3720	7430	5000000	3350000	2520000	8220000
SC63	348.0	2268	552	4710.0	965	917000	11700	7870000	15700000	40000000	1070000	404000	3410000
SC64	260.0	387	567	1360.0	219	229000	16500	9010000	18000000	40000000	1250000	3330000	142000
SC65	13.0	2024	303	6110.0	891	329000	5520	1800000	3600000	40000000	5080000	316000	10000000
SC66	18.0	964	1018	678.0	653	1530000	7350	6670000	13300000	40000000	3570000	3330000	10000000
SC67	168.0	2012	364	6060.0	853	340000	6850	3730000	7460000	40000000	3400000	508000	10000000
SC69	263.0	5686	29664	2970.0	9510	9e+07	39400	15100	30300	4080000	9380000	1430000	6450000
SC70	156.0	17641	3758	17000.0	5310	1e+07	109000	565000	1130000	4200000	5920000	802000	5660000
SC71BC	40.0	0	0	13100.0	78200	2e+07	303000	17200	34500	7140000	10700000	2220000	10000000
SC72A	40.0	5346	521	23900.0	1450	1760000	46800	3330000	6670000	40000000	1070000	493000	10000000
SC72BC	284.0	5600	0	2330.0	21700	2000000	117000	17200	34300	2480000	5330000	2310000	10000000
SC73	197.0	2e+05	2330	94200.0	4590	24200	500000	14900000	29900000	40000000	30000000	3330000	10000000
SC74	403.0	362	560	415.0	246	2e+07	26200	10000000	20000000	40000000	1460000	1590000	10000000
SC75	77.0	2626	3517	6560.0	1920	1e+07	86200	12800000	25600000	40000000	10700000	3330000	10000000
SC76	240.0	1389	333	13300.0	651	1380	16200	5290000	10600000	27300000	3280000	3330000	10000000
SC77	854.0	0	4949	102000	6530	4460000	319000	12800000	25600000	40000000	20900000	3330000	10000000
SC80	1774.0	916	188	6900.0	386	1120000	35500	6410000	12800000	40000000	2180000	852000	232000
SC81ABCD	1478.0	902	3924	600.0	1570	4890000	122000	2280000	4570000	3850000	4950000	2360000	5530000
SC82	2380.0	4277	537	37400.0	1370	853000	93200	216000	432000	40000000	3810000	2170000	198000
SC83	747.0	6478	1206	35300.0	1510	8700000	76500	5000000	10000000	27300000	7830000	3330000	134000
SC84	579.0	1422	244	2960.0	737	6090	16800	14800	29500	9230000	2160000	1000000	10000000
SC85	451.0	1547	485	1340.0	894	486000	10400	6020	12000	9230000	11000000	691000	10000000
SC86	369.0	4896	840	7000.0	1530	485000	18800	10000000	20000000	14000000	2620000	564000	7500000
SC87	178.0	777	618	3320.0	731	15000	15400	862000	1720000	16000000	1220000	474000	55600
SC88	119.0	2529	1553	3900.0	1440	294000	19500	2820000	5630000	40000000	4620000	446000	10000000
SC89	162.0	2271	398	2760.0	669	196000	7070	1180000	2370000	40000000	426000	223000	10000000
SC90	194.0	1835	346	3520.0	890	216000	8110	3860000	7720000	23500000	4650000	260000	10000000
SC92	323.0	2186	376	2390.0	1000	207000	7480	5620000	11200000	24000000	3180000	739000	10000000
SC93	272.0	304	451	103.0	226	222000	12700	858	1720	9520000	1920000	1970000	2250000

N/A = Data Not Available.

(Continued). Application Rates for the Liquid Phase Drilling Wastes.

Sump Number	Ni	Cd (m3/ha)	Pb
SC49	1670000	300000	2000000
SC50	1670000	300000	2000000
SC51	1670000	300000	2000000
SC52A	1670000	300000	2000000
SC52B	1670000	300000	2000000
SC52C	1670000	300000	2000000
SC53	1670000	300000	2000000
SC54	373000	158000	623000
SC55	877000	300000	2000000
SC56A	1670000	300000	2000000
SC56B	1670000	300000	2000000
SC56C	1670000	300000	2000000
SC57	221000	100000	467000
SC58	1670000	300000	2000000
SC59	1670000	300000	2000000
SC60	573000	300000	1490000
SC61	400000	111000	521000
SC62AB	773000	300000	1220000
SC62CD	479000	243000	1280000
SC63	758000	300000	809000
SC64	1670000	300000	2000000
SC65	1670000	300000	2000000
SC66	1670000	300000	2000000
SC67	449000	300000	2000000
SC69	481000	130000	704000
SC70	507000	150000	693000
SC71BC	746000	188000	1040000
SC72A	962000	300000	2000000
SC72BC	371000	167000	737000
SC73	1670000	300000	2000000
SC74	1670000	300000	2000000
SC75	1670000	300000	2000000
SC76	1670000	300000	2000000
SC77	1670000	300000	2000000
SC80	1670000	300000	2000000
SC81ABCD	473000	161000	751000
SC82	1670000	300000	2000000
SC83	1140000	300000	2000000
SC84	1670000	300000	1450000
SC85	904000	205000	1220000
SC86	412000	300000	2000000
SC87	833000	300000	2000000
SC88	1670000	300000	2000000
SC89	294000	300000	2000000
SC90	1670000	300000	2000000
SC92	1670000	300000	2000000
SC93	1020000	300000	1660000

(Concluded). Application Rates for the Liquid Phase Drilling Wastes.

Sump Number	Liquid Vol, m3	EC	SAR	Cl	Na	NH4&NO3	B	Oil 10000	Oil 20000	Cu	Zn	Ni	Cr
		(m3/ha)											
SC94	501.0	1502	623	1210.0	785	705000	16400	391000	781000	40000000	2540000	3330000	10000000
SC95	806.0	1729	225	12100.0	726	614000	40200	1180000	2370000	20000000	2040000	3330000	10000000
SC96	222.0	817	495	1160.0	403	2e+07	15400	7410000	14800000	40000000	1860000	3330000	181000
SC97	528.0	820	742	10700.0	639	83200	64300	7550000	15100000	10000000	4020000	653000	4630000
SC98	593.0	99	283	72.3	324	410000	84000	5620000	11200000	7020000	30000000	3330000	10000000
SC99	209.0	1557	2489	1130.0	1530	590000	35300	1330	2660	4210000	6120000	1250000	10000000
SC100	555.0	1466	327	5590.0	764	1240000	23300	383000	766000	16200000	6520000	3330000	1530000
SC101	277.0	1274	634	1390.0	676	301000	19100	72500	145000	40000000	5710000	3330000	10000000
SC102	60.0	101	1402	61.8	1080	12700	74900	5000000	10000000	2800000	6820000	1090000	5710000
SC103	105.0	1236	534	6030.0	622	566000	12500	4500000	9010000	26100000	3950000	1260000	10000000
SC104	195.0	626	342	2190.0	603	146000	9170	5620000	11200000	3390000	1500000	376000	10000000
SC105	267.0	204	627	131.0	485	72200	29800	14500	29000	18200000	2080000	667000	10000000
SC106	298.0	137	610	93.3	511	125000	31900	1180000	2370000	7140000	5490000	685000	10000000
SC107	470.0	292	223	407.0	255	22900	24500	380000	760000	40000000	600000	452000	10000000
SC108	1148.0	720	1419	563.0	669	145000	13100	325	649	14100000	1100000	1710000	10000000
SC201	454.0	1055	330	850.0	635	110000	87000	92600	185000	40000000	30000000	1300000	303000
SC202	1815.0	1356	1137	21200.0	797	7270000	111000	52400	105000	40000000	232000	3330000	10000000
SC203	412.0	5212	582	21700.0	1660	5000000	500000	4780000	9570000	40000000	3950000	3330000	10000000
SC204	1822.0	986	325	3790.0	515	195000	69900	1270000	2540000	40000000	1640000	3330000	10000000
SC205	76.0	79	1782	48.3	505	34800	253000	2650000	5290000	40000000	30000000	3330000	10000000
SC206	202.0	23	17	6.9	6	128000	500000	4740000	9480000	40000000	30000000	3330000	10000000

Sump Number	Ni	Cd	Pb
		(m3/ha)	
SC94	1670000	300000	2000000
SC95	1670000	300000	2000000
SC96	1670000	300000	2000000
SC97	899000	300000	2000000
SC98	962000	300000	1250000
SC99	394000	300000	781000
SC100	1150000	300000	1490000
SC101	1670000	300000	2000000
SC102	370000	96800	496000
SC103	1670000	300000	2000000
SC104	352000	100000	504000
SC105	1670000	300000	2000000
SC106	1040000	300000	1360000
SC107	1670000	300000	2000000
SC108	1670000	300000	2000000
SC201	1670000	300000	2000000
SC202	1670000	300000	2000000
SC203	1670000	300000	2000000
SC204	1670000	300000	2000000
SC205	1670000	300000	2000000
SC206	1670000	300000	2000000

APPENDIX 23: AREA REQUIRED FOR LAND APPLICATION OF THE LIQUID PHASE DRILLING WASTES

Area Required for Land Application of the Liquid Phase Drilling Wastes.

Sump Number	Liquid Vol, m3	EC	SAR	Cl	Na	NH4&NO3	B	--- Oil --- 10000	20000	Cu	Zn	V	Cr	Ni	Cd	Pb
		(ha)														
SC1	N/A															
SC2	N/A															
SC4	N/A															
SC5	N/A															
SC6	N/A															
SC8	N/A															
SC9A	45.0	0.10	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC9BD	192.0	0.24	0.06	0.22	0.15	0.00	0.00	1.04	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC10	36.0	0.03	0.08	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC11	21.0	0.01	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC12	24.0	0.15	0.03	0.25	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC13	148.0	0.17	0.54	0.06	0.27	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC15	278.0	0.09	0.76	0.02	0.23	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC16	75.0	0.02	0.19	0.01	0.06	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC17	137.0	0.04	0.30	0.02	0.11	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC18	108.0	0.09	0.46	0.10	0.16	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC19A	2351.0	9.98	4.07	11.94	6.16	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
SC21	N/A															
SC22	N/A															
SC23	N/A															
SC24	645.8	0.26	1.73	0.18	0.87	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
SC25	1310.0	0.08	3.35	0.22	1.39	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC26	112.0	0.04	0.78	0.07	0.30	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC27	632.0	0.30	2.09	0.08	1.59	0.12	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
SC28	268.0	0.28	0.59	0.23	0.55	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC29	1147.0	6.93	2.02	12.00	8.70	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC30A	537.6	0.17	0.07	0.07	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC30B	338.0	2.52	0.97	3.67	3.04	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC31	357.0	1.34	0.66	1.89	1.88	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC32	1204.0	1.14	2.60	0.31	1.15	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC33	24.0	0.01	0.05	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC34	2773.0	4.54	3.80	0.10	1.54	0.02	0.06	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00
SC35	1886.0	1.29	3.43	0.31	2.83	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00
SC36	227.0	2.44	0.45	3.63	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC37	675.0	0.06	0.70	0.04	0.30	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC38	648.0	0.06	0.73	0.03	0.31	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC39	483.0	0.64	1.30	0.11	1.34	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC40	4146.0	3.38	7.82	0.97	7.22	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
SC41	817.0	0.68	1.88	0.31	1.59	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC42	369.0	0.46	0.55	0.10	0.80	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC43	513.0	0.61	1.29	0.34	1.35	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC44	514.0	1.10	1.46	0.61	2.16	0.00	0.08	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC45	1562.0	1.84	4.46	0.54	3.51	0.00	0.07	0.03	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00
SC46	509.0	0.82	1.72	0.67	1.60	0.00	0.01	0.30	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC47	368.0	0.19	0.56	0.02	0.38	0.17	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC48	1083.0	0.48	3.02	0.12	0.94	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Areas could not be calculated where volume data not available; All calculated areas <0.01 ha are reported as 0;
N/A = Data Not Available.

(Continued). Area Required for Land Application of the Liquid Phase Drilling Wastes.

Sump Number	Liquid Vol, m3	EC	SAR	Cl	Na	NH4&NO3	B	--- Oil ---		Cu	Zn	V	Cr	Ni	Cd	Pb
								10000	20000							
									(ha)							
SC49	469.0	0.56	1.38	0.29	1.15	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC50	882.0	1.63	2.94	0.16	3.43	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
SC51	N/A															
SC52A	N/A															
SC52B	N/A															
SC52C	N/A															
SC53	500.0	0.69	0.24	0.89	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC54	339.0	0.34	0.30	0.05	0.37	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC55	303.0	0.19	0.89	0.02	0.44	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC56A	220.0	0.43	0.08	0.66	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC56B	27.0	1.80	0.31	2.52	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC56C	14.0	0.11	0.02	0.16	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC57	2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC58	210.0	1.49	0.66	2.25	0.62	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC59	959.0	1.35	0.61	1.83	0.78	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC60	694.0	1.21	1.80	0.41	0.71	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC61	975.0	3.51	3.65	0.93	2.36	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
SC62AB	22.0	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC62CD	683.0	0.65	0.38	0.63	0.69	0.00	0.01	0.18	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC63	348.0	0.15	0.63	0.07	0.36	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC64	260.0	0.67	0.46	0.19	1.19	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC65	13.0	0.01	0.04	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC66	18.0	0.02	0.02	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC67	168.0	0.08	0.46	0.03	0.20	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC69	263.0	0.05	0.01	0.09	0.03	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC70	156.0	0.01	0.04	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC71BC	40.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC72A	40.0	0.01	0.08	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC72BC	284.0	0.05	0.00	0.12	0.01	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC73	197.0	0.00	0.08	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC74	403.0	1.11	0.72	0.97	1.64	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC75	77.0	0.03	0.02	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC76	240.0	0.17	0.72	0.02	0.37	0.17	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC77	854.0	0.00	0.17	0.01	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC80	1774.0	1.94	9.45	0.26	4.59	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00
SC81ABCD	1478.0	1.64	0.38	2.46	0.94	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
SC82	2380.0	0.56	4.43	0.06	1.73	0.00	0.03	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00
SC83	747.0	0.12	0.62	0.02	0.49	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
SC84	579.0	0.41	2.37	0.20	0.79	0.10	0.03	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC85	451.0	0.29	0.93	0.34	0.50	0.00	0.04	0.07	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC86	369.0	0.08	0.44	0.05	0.24	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC87	178.0	0.23	0.29	0.05	0.24	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC88	119.0	0.05	0.08	0.03	0.08	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC89	162.0	0.07	0.41	0.06	0.24	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC90	194.0	0.11	0.56	0.06	0.22	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC92	323.0	0.15	0.86	0.14	0.32	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC93	272.0	0.90	0.60	2.64	1.20	0.00	0.02	0.32	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Areas could not be calculated where volume data not available; All calculated areas <0.01 ha are reported as 0;
N/A = Data Not Available.

(Concluded). Area Required for Land Application of the Liquid Phase Drilling Wastes.

Sump Number	Liquid Vol, m3	EC	SAR	Cl	Na	NH4&NO3	B	--- Oil --- 10000	20000	Cu	Zn	V	Cr	Ni	Cd	Pb
		(ha)														
SC94	501.0	0.33	0.80	0.42	0.64	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC95	806.0	0.47	3.58	0.07	1.11	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC96	222.0	0.27	0.45	0.19	0.55	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC97	528.0	0.64	0.71	0.05	0.83	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC98	593.0	5.97	2.10	8.21	1.83	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC99	209.0	0.13	0.08	0.18	0.14	0.00	0.01	0.16	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC100	555.0	0.38	1.70	0.10	0.73	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC101	277.0	0.22	0.44	0.20	0.41	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC102	60.0	0.60	0.04	0.97	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC103	105.0	0.08	0.20	0.02	0.17	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC104	195.0	0.31	0.57	0.09	0.32	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC105	267.0	1.31	0.43	2.04	0.55	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC106	298.0	2.18	0.49	3.19	0.58	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC107	470.0	1.61	2.10	1.16	1.84	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC108	1148.0	1.59	0.81	2.04	1.72	0.01	0.09	3.54	1.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC201	454.0	0.43	1.38	0.53	0.72	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC202	1815.0	1.34	1.60	0.09	2.28	0.00	0.02	0.03	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.00
SC203	412.0	0.08	0.71	0.02	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC204	1822.0	1.85	5.60	0.48	3.54	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
SC205	76.0	0.96	0.04	1.57	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC206	202.0	8.69	11.91	29.42	31.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

All calculated areas <0.01 ha are reported as 0.

APPENDIX 24: LIMITING ANALYTES REQUIRING >1 HA AREA FOR LAND APPLICATION OF THE LIQUID PHASE DRILLING WASTES

Limiting Analytes Requiring >1 ha Area for Land Application of the Liquid Phase Drilling Wastes.

Sump Number	Liquid Vol, m3	EC	SAR	Cl	Na	Oil		EC50 15min(%)	Trout Survival
						10000	20000		
		(ha)							
SC1	N/A							11	0
SC2	N/A							16	0
SC4	N/A							25	0
SC5	N/A							13	0
SC6	N/A							2	0
SC8	N/A							13	0
SC9A	45.0							11	0
SC9BD	192.0					1.04		0	0
SC10	36.0							52	0
SC11	21.0							100	0
SC12	24.0							22	0
SC13	148.0							3	3
SC15	278.0							31	0
SC16	75.0							100	0
SC17	137.0							12	0
SC18	108.0							43	0
SC19A	2351.0	9.98	4.07	11.94	6.16			83	0
SC21	N/A							86	1
SC22	N/A							11	0
SC23	N/A							2	0
SC24	645.8		1.73					4	0
SC25	1310.0		3.35		1.39			81	0
SC26	112.0							9	0
SC27	632.0		2.09		1.59			0	0
SC28	268.0							95	0
SC29	1147.0	6.93	2.02	12.00	8.70			8	0
SC30A	537.6							100	2
SC30B	338.0	2.52		3.67	3.04			14	0
SC31	357.0	1.34		1.89	1.88			100	3
SC32	1204.0	1.14	2.60		1.15			34	0
SC33	24.0							4	0
SC34	2773.0	4.54	3.80		1.54			26	0
SC35	1886.0	1.29	3.43		2.83			21	0
SC36	227.0	2.44		3.63				100	0
SC37	675.0							100	0
SC38	648.0							100	0
SC39	483.0		1.30		1.34			34	0
SC40	4146.0	3.38	7.82		7.22			100	0
SC41	817.0		1.88		1.59			10	0
SC42	369.0							100	1
SC43	513.0		1.29		1.35			10	0
SC44	514.0	1.10	1.46		2.16			27	0
SC45	1562.0	1.84	4.46		3.51			10	0
SC46	509.0		1.72		1.60			13	0
SC47	368.0							81	0
SC48	1083.0		3.02					7	0
SC49	469.0		1.38		1.15			41	0

N/A = Data Not Available; Areas could not be calculated where volume data not available.

(Continued). Limiting Analytes Requiring >1 ha Area for Land Application of the Liquid Phase Drilling Wastes.

Sump Number	Liquid Vol, m3	EC	SAR	Cl	Na	---- Oil ---		EC50 15min(%)	Trout Survival
						10000	20000		
		----------	----------	(ha)	----------	----------	----------		
SC50	882.0	1.63	2.94		3.43			39	0
SC51	N/A							100	2
SC52A	N/A							100	0
SC52B	N/A							100	3
SC52C	N/A							100	3
SC53	500.0							100	2
SC54	339.0							100	1
SC55	303.0							46	0
SC56A	220.0							100	0
SC56B	27.0	1.80		2.52				100	0
SC56C	14.0							7	0
SC57	2.0							1	0
SC58	210.0	1.49		2.25				42	0
SC59	959.0	1.35		1.83				100	1
SC60	694.0	1.21	1.80					3	0
SC61	975.0	3.51	3.65		2.36			18	0
SC62AB	22.0							51	1
SC62CD	683.0							9	0
SC63	348.0							70	0
SC64	260.0				1.19			100	3
SC65	13.0							100	0
SC66	18.0							80	3
SC67	168.0							47	0
SC69	263.0							2	0
SC70	156.0							5	0
SC71BC	40.0							51	2
SC72A	40.0							17	0
SC72BC	284.0							5	0
SC73	197.0							100	3
SC74	403.0	1.11			1.64			100	0
SC75	77.0							100	3
SC76	240.0							86	0
SC77	854.0							100	2
SC80	1774.0	1.94	9.45		4.59			33	0
SC81ABCD	1478.0	1.64		2.46				14	0
SC82	2380.0		4.43		1.73			40	0
SC83	747.0							82	0
SC84	579.0		2.37					8	0
SC85	451.0							6	0
SC86	369.0							28	0
SC87	178.0							8	0
SC88	119.0							63	0
SC89	162.0							42	0
SC90	194.0							13	0
SC92	323.0							27	0
SC93	272.0			2.64	1.20			67	0
SC94	501.0							100	N/A

N/A = Data Not Available.

(Concluded). Limiting Analytes Requiring >1 ha Area for Land Application of the Liquid Phase Drilling Wastes.

Sump Number	Liquid Vol, m3	EC	SAR	Cl	Na	---- Oil ---		EC50 15min(%)	Trout Survival
						10000	20000		
		---------------- (ha) ----------------							
SC95	806.0		3.58		1.11			100	0
SC96	222.0							100	2
SC97	528.0							72	0
SC98	593.0	5.97	2.10	8.21	1.83			38	0
SC99	209.0							3	0
SC100	555.0		1.70					29	0
SC101	277.0							100	3
SC102	60.0							73	0
SC103	105.0							38	0
SC104	195.0							11	0
SC105	267.0	1.31		2.04				21	0
SC106	298.0	2.18		3.19				9	0
SC107	470.0	1.61	2.10	1.16	1.84			33	0
SC108	1148.0	1.59		2.04	1.72	3.54	1.77	5	0
SC201	454.0		1.38					3	N/A
SC202	1815.0	1.34	1.60		2.28			23	N/A
SC203	412.0							98	N/A
SC204	1822.0	1.85	5.60		3.54			23	N/A
SC205	76.0			1.57				1	N/A
SC206	202.0	8.69	11.91	29.42	31.27			16	N/A

APPENDIX 25: THICKNESS OF THE LIQUID PHASE DRILLING WASTE LAYER APPLIED

Thickness of the Liquid Phase Drilling Waste Layer Applied.

Sump Number	Liquid Vol, m3	EC	SAR	Cl	Na	NH4&NO3	B	Oil 10000	Oil 20000	Cu	Zn	V	Cr
		(cm)											
SC1	N/A	48	5	106.00	6.52	58800	420			400000	4060	33300	100000
SC2	N/A	86	4	102.00	8.63	1550.00	570			400000	38100	12000	100000
SC4	N/A	3	2	0.90	1.42	113000	360			400000	300000	33300	1460
SC5	N/A	5	2	1.29	2.07	167000	719			400000	300000	33300	100000
SC6	N/A	58	98	7.77	29.20	121000	5000	10.40	20.80	400000	16700	33300	100000
SC8	N/A	94	3	104.00	7.44	67000	408			100000	29800	23100	3020
SC9A	45.0	4	133	69.60	84.00	1000000	893	282	565.00	33900	73200	10400	41700
SC9BD	192.0	8	32	8.76	12.50	3380.00	595	1.85	3.69	29200	7480	9300	40400
SC10	36.0	13	5	117.00	6.27	286000	588	926	1850.00	400000	37500	7040	100000
SC11	21.0	25	8	82.80	15.20	11600	92.600	29200	58300.00	42600	56600	13200	100000
SC12	24.0	2	9	0.97	3.40	307.00	5000	64100	128000.00	400000	300000	33300	2450
SC13	148.0	9	3	24.10	5.51	244.00	85.200	11700	23300.00	55600	6160	2340	7790
SC15	278.0	29	4	152.00	11.80	2670.00	119	50000	100000.00	400000	24800	4310	100000
SC16	75.0	33	4	137.00	12.70	4890.00	91.700	40000	80000.00	267000	14800	18200	100000
SC17	137.0	32	5	61.80	12.10	941.00	50.600	1e+05	267000.00	222000	13600	2070	100000
SC18	108.0	13	2	10.30	6.90	3180.00	207	36200	72500.00	160000	31300	19600	1060
SC19A	2351.0	2	6	1.97	3.82	5470.00	534	2e+05	455000.00	176000	42300	33300	100000
SC21	N/A	9	2	2.48	1.44	563000	29.500			400000	8310	33300	100000
SC22	N/A	152	4	22.50	9.25	112000	125			400000	300000	3220	4160
SC23	N/A	107	3	33.90	8.65	10000	68.000			400000	36100	767	8400
SC24	645.8	25	4	35.90	7.39	863.00	287	2200	4410.00	19600	32800	6000	31600
SC25	1310.0	156	4	58.80	9.41	66300	307	69400	139000.00	400000	47900	33300	100000
SC26	112.0	29	1	15.20	3.79	81.30	136	5990	12000.00	66700	20000	33300	1040
SC27	632.0	21	3	83.90	3.97	52.30	316	3940	7870.00	31700	22000	8470	799
SC28	268.0	10	5	11.90	4.86	1270.00	180	41000	82000.00	211000	15200	33300	2740
SC29	1147.0	2	6	0.96	1.32	2620.00	153	45000	90100.00	400000	10100	33300	51700
SC30A	537.6	32	82	80.80	33.50	136000	1690	34600	69200.00	400000	127000	33300	100000
SC30B	338.0	1	3	0.92	1.11	62500	175	75200	150000.00	49400	8310	33300	100000
SC31	357.0	3	5	1.89	1.90	1550.00	545	34000	67900.00	400000	16900	33300	31300
SC32	1204.0	11	5	38.80	10.50	11600	168	69400	139000.00	400000	35300	33300	22200
SC33	24.0	30	5	119.00	11.40	16700	90.900	53800	108000.00	18700	41700	4850	3140
SC34	2773.0	6	7	269.00	18.00	1650.00	485	1e+05	225000.00	194000	46900	9740	5000
SC35	1886.0	15	6	61.30	6.66	20500	423	69900	140000.00	400000	32800	12000	3250
SC36	227.0	1	5	0.63	3.32	2200.00	823	56200	112000.00	400000	20500	33300	100000
SC37	675.0	109	10	186.00	22.20	16600	273	2e+05	455000.00	400000	90000	9200	69800
SC38	648.0	102	9	230.00	20.80	22200	272	1e+05	253000.00	400000	67200	6070	44800
SC39	483.0	8	4	45.20	3.61	4470.00	279	7350	14700.00	400000	21000	33300	2640
SC40	4146.0	12	5	42.60	5.74	100000	694	42900	85800.00	400000	25900	23800	12000
SC41	817.0	12	4	26.20	5.15	1280.00	326	41000	82000.00	122000	18600	15600	100000
SC42	369.0	8	7	37.80	4.61	1870.00	244	75200	150000.00	158000	25900	20000	100000
SC43	513.0	8	4	14.90	3.80	3420.00	73.900	3e+05	606000.00	400000	19200	3710	100000
SC44	514.0	5	4	8.48	2.38	2280.00	61.300	224	448.00	400000	14000	20000	100000
SC45	1562.0	8	4	28.90	4.45	12700	226	578	1160.00	300000	22000	18100	1050
SC46	509.0	6	3	7.58	3.18	3070.00	503	17.20	34.50	88900	17800	17900	51300
SC47	368.0	19	7	152.00	9.57	21.60	526	13600	27300.00	400000	42700	33300	2980
SC48	1083.0	23	4	90.40	11.50	6190.00	328	4610	9220.00	70600	31500	6610	100000
SC49	469.0	8	3	16.30	4.08	6040.00	113	13600	27300.00	133000	11700	33300	100000

N/A = Data Not Available.

(Continued). Thickness of the Liquid Phase Drilling Waste Layer Applied.

Sump Number	Ni	Cd	Pb
	--------	(cm)	-------
SC1	16700	3000	20000
SC2	16700	3000	20000
SC4	16700	3000	20000
SC5	16700	3000	20000
SC6	16700	3000	20000
SC8	16700	3000	20000
SC9A	4240	1150	5920
SC9BD	3410	1360	6020
SC10	16700	3000	20000
SC11	3210	3000	7810
SC12	16700	3000	20000
SC13	8930	3000	20000
SC15	16700	3000	20000
SC16	16700	3000	20000
SC17	16700	3000	20000
SC18	16700	3000	13000
SC19A	11900	3000	20000
SC21	16700	3000	20000
SC22	16700	3000	20000
SC23	16700	3000	20000
SC24	4410	957	4270
SC25	7980	3000	20000
SC26	16700	3000	20000
SC27	16700	3000	20000
SC28	16700	3000	20000
SC29	16700	3000	20000
SC30A	16700	3000	20000
SC30B	7940	3000	12600
SC31	16700	3000	20000
SC32	10900	3000	20000
SC33	16700	3000	20000
SC34	16700	3000	20000
SC35	16700	3000	20000
SC36	16700	3000	20000
SC37	16700	3000	20000
SC38	16700	3000	12300
SC39	16700	3000	20000
SC40	16700	3000	20000
SC41	11400	3000	14000
SC42	16700	3000	20000
SC43	16700	3000	20000
SC44	16700	3000	20000
SC45	16700	3000	20000
SC46	8620	3000	12300
SC47	16700	3000	20000
SC48	10000	3000	12300
SC49	16700	3000	20000

(Continued). Thickness of the Liquid Phase Drilling Waste Layer Applied.

Sump Number	Liquid Vol, m3	EC	SAR	Cl	Na	NH4&NO3	B	Oil 10000	Oil 20000	Cu	Zn	V	Cr
		(cm)											
SC50	882.0	5	3	54.10	2.57	29100	292	15800	31600.00	400000	13400	13600	1100
SC51	N/A	3822	6	432.00	14.90	25.00	719	1e+05	267000.00	400000	83300	33300	100000
SC52A	N/A	2	1	0.19	0.41	9650.00	3410	1e+05	200000.00	400000	4830	33300	100000
SC52B	N/A	23	11	6.99	4.69	4910.00	524	2e+05	455000.00	400000	50800	33300	100000
SC52C	N/A	147	17	65.80	12.30	2350.00	5000	42900	85800.00	400000	300000	33300	100000
SC53	500.0	7	21	5.60	13.40	154000	1270	1e+05	225000.00	400000	91800	33300	100000
SC54	339.0	10	11	65.00	9.20	113000	193	2e+05	339000.00	38800	41700	33300	60600
SC55	303.0	16	3	141.00	6.83	906.00	604	1e+05	290000.00	250000	11000	33300	1830
SC56A	220.0	1	4	0.41	1.08	23500	270	63300	127000.00	400000	7040	33300	2200
SC56B	27.0	1	7	0.87	2.73	23500	2130	1e+05	225000.00	400000	15500	33300	28600
SC56C	14.0	1	7	0.87	2.53	197.00	629	78100	156000.00	400000	14800	33300	8620
SC57	2.0	31	0	22.20	123.00	200000	1250	3380	6760.00	29900	18200	11100	100000
SC58	210.0	1	3	0.94	3.37	3810.00	350	45000	90100.00	400000	19700	33300	46500
SC59	959.0	7	16	5.23	12.40	1040.00	3700	33300	66700.00	400000	62100	33300	5540
SC60	694.0	6	4	17.10	9.74	6250.00	1070	93500	187000.00	167000	27900	33300	100000
SC61	975.0	3	3	10.50	4.13	413.00	633	2040	4080.00	16900	17200	10500	38500
SC62AB	22.0	0	0	108.00	292.00	207000	1600	10.80	21.60	95200	51400	23800	73200
SC62CD	683.0	11	18	10.90	9.94	2410.00	551	37.20	74.30	50000	33500	25200	82200
SC63	348.0	23	6	47.10	9.65	9170.00	117	78700	157000.00	400000	10700	4040	34100
SC64	260.0	4	6	13.60	2.19	2290.00	165	90100	180000.00	400000	12500	33300	1420
SC65	13.0	20	3	61.10	8.91	3290.00	55.200	18000	36000.00	400000	50800	3160	100000
SC66	18.0	10	10	6.78	6.53	15300	73.500	66700	133000.00	400000	35700	33300	100000
SC67	168.0	20	4	60.60	8.53	3400.00	68.500	37300	74600.00	400000	34000	5080	100000
SC69	263.0	57	297	29.70	95.10	851000	394	151	303.00	40800	93800	14300	64500
SC70	156.0	176	38	170.00	53.10	108000	1090	5650	11300.00	42000	59200	8020	56600
SC71BC	40.0	0	0	131.00	782.00	242000	3030	172	345.00	71400	107000	22200	100000
SC72A	40.0	53	5	239.00	14.50	17600	468	33300	66700.00	400000	10700	4930	100000
SC72BC	284.0	56	0	23.30	217.00	20000	1170	172	343.00	24800	53300	23100	100000
SC73	197.0	2219	23	942.00	45.90	242.00	5000	1e+05	299000.00	400000	300000	33300	100000
SC74	403.0	4	6	4.15	2.46	151000	262	1e+05	200000.00	400000	14600	15900	100000
SC75	77.0	26	35	65.60	19.20	116000	862	1e+05	256000.00	400000	107000	33300	100000
SC76	240.0	14	3	133.00	6.51	13.80	162	52900	106000.00	273000	32800	33300	100000
SC77	854.0	0	49	1020.00	65.30	44600	3190	1e+05	256000.00	400000	209000	33300	100000
SC80	1774.0	9	2	69.00	3.86	11200	355	64100	128000.00	400000	21800	8520	2320
SC81ABCD	1478.0	9	39	6.00	15.70	48900	1220	22800	45700.00	38500	49500	23600	55300
SC82	2380.0	43	5	374.00	13.70	8530.00	932	2160	4320.00	400000	38100	21700	1980
SC83	747.0	65	12	353.00	15.10	87000	765	50000	100000.00	273000	78300	33300	1340
SC84	579.0	14	2	29.60	7.37	60.90	168	148	295.00	92300	21600	10000	100000
SC85	451.0	15	5	13.40	8.94	4860.00	104	60.20	120.00	92300	110000	6910	100000
SC86	369.0	49	8	70.00	15.30	4850.00	188	1e+05	200000.00	140000	26200	5640	75000
SC87	178.0	8	6	33.20	7.31	150.00	154	8620	17200.00	160000	12200	4740	556
SC88	119.0	25	16	39.00	14.40	2940.00	195	28200	56300.00	400000	46200	4460	100000
SC89	162.0	23	4	27.60	6.69	1960.00	70.700	11800	23700.00	400000	4260	2230	100000
SC90	194.0	18	3	35.20	8.90	2160.00	81.100	38600	77200.00	235000	46500	2600	100000
SC92	323.0	22	4	23.90	10.00	2070.00	74.800	56200	112000.00	240000	31800	7390	100000
SC93	272.0	3	5	1.03	2.26	2220.00	127	8.58	17.20	95200	19200	19700	22500
SC94	501.0	15	6	12.10	7.85	7050.00	164	3910	7810.00	400000	25400	33300	100000

N/A = Data Not Available.

(Continued). Thickness of the Liquid Phase Drilling Waste Layer Applied.

Sump Number	Ni	Cd	Pb
	--------	(cm)	-------
SC50	16700	3000	20000
SC51	16700	3000	20000
SC52A	16700	3000	20000
SC52B	16700	3000	20000
SC52C	16700	3000	20000
SC53	16700	3000	20000
SC54	3730	1580	6230
SC55	8770	3000	20000
SC56A	16700	3000	20000
SC56B	16700	3000	20000
SC56C	16700	3000	20000
SC57	2210	1000	4670
SC58	16700	3000	20000
SC59	16700	3000	20000
SC60	5730	3000	14900
SC61	4000	1110	5210
SC62AB	7730	3000	12200
SC62CD	4790	2430	12800
SC63	7580	3000	8090
SC64	16700	3000	20000
SC65	16700	3000	20000
SC66	16700	3000	20000
SC67	4490	3000	20000
SC69	4810	1300	7040
SC70	5070	1500	6930
SC71BC	7460	1880	10400
SC72A	9620	3000	20000
SC72BC	3710	1670	7370
SC73	16700	3000	20000
SC74	16700	3000	20000
SC75	16700	3000	20000
SC76	16700	3000	20000
SC77	16700	3000	20000
SC80	16700	3000	20000
SC81ABCD	4730	1610	7510
SC82	16700	3000	20000
SC83	11400	3000	20000
SC84	16700	3000	14500
SC85	9040	2050	12200
SC86	4120	3000	20000
SC87	8330	3000	20000
SC88	16700	3000	20000
SC89	2940	3000	20000
SC90	16700	3000	20000
SC92	16700	3000	20000
SC93	10200	3000	16600
SC94	16700	3000	20000

(Concluded). Thickness of the Liquid Phase Drilling Waste Layer Applied.

Sump Number	Liquid Vol, m3	EC	SAR	Cl	Na	NH4&NO3	B	Oil 10000	Oil 20000	Cu	Zn	V	Cr
		(cm)											
SC95	806.0	17	2	121.00	7.26	6140.00	402	11800	23700.00	200000	20400	33300	100000
SC96	222.0	8	5	11.60	4.03	174000	154	74100	148000.00	400000	18600	33300	1810
SC97	528.0	8	7	107.00	6.39	832.00	643	75500	151000.00	100000	40200	6530	46300
SC98	593.0	1	3	0.72	3.24	4100.00	840	56200	112000.00	70200	300000	33300	100000
SC99	209.0	16	25	11.30	15.30	5900.00	353	13.30	26.60	42100	61200	12500	100000
SC100	555.0	15	3	55.90	7.64	12400	233	3830	7660.00	162000	65200	33300	15300
SC101	277.0	13	6	13.90	6.76	3010.00	191	725	1450.00	400000	57100	33300	100000
SC102	60.0	1	14	0.62	10.80	127.00	749	50000	100000.00	28000	68200	10900	57100
SC103	105.0	12	5	60.30	6.22	5660.00	125	45000	90100.00	261000	39500	12600	100000
SC104	195.0	6	3	21.90	6.03	1460.00	91.700	56200	112000.00	33900	15000	3760	100000
SC105	267.0	2	6	1.31	4.85	722.00	298	145	290.00	182000	20800	6670	100000
SC106	298.0	1	6	0.93	5.11	1250.00	319	11800	23700.00	71400	54900	6850	100000
SC107	470.0	3	2	4.07	2.55	229.00	245	3800	7600.00	400000	6000	4520	100000
SC108	1148.0	7	14	5.63	6.69	1450.00	131	3.25	6.49	141000	11000	17100	100000
SC201	454.0	11	3	8.50	6.35	1100.00	870	926	1850.00	400000	300000	13000	3030
SC202	1815.0	14	11	212.00	7.97	72700	1110	524	1050.00	400000	2320	33300	100000
SC203	412.0	52	6	217.00	16.60	50000	5000	47800	95700.00	400000	39500	33300	100000
SC204	1822.0	10	3	37.90	5.15	1950.00	699	12700	25400.00	400000	16400	33300	100000
SC205	76.0	1	18	0.48	5.05	348.00	2530	26500	52900.00	400000	300000	33300	100000
SC206	202.0	0	0	0.07	0.06	1280.00	5000	47400	94800.00	400000	300000	33300	100000

Sump Number	Ni	Cd	Pb
		(cm)	
SC95	16700	3000	20000
SC96	16700	3000	20000
SC97	8990	3000	20000
SC98	9620	3000	12500
SC99	3940	3000	7810
SC100	11500	3000	14900
SC101	16700	3000	20000
SC102	3700	968	4960
SC103	16700	3000	20000
SC104	3520	1000	5040
SC105	16700	3000	20000
SC106	10400	3000	13600
SC107	16700	3000	20000
SC108	16700	3000	20000
SC201	16700	3000	20000
SC202	16700	3000	20000
SC203	16700	3000	20000
SC204	16700	3000	20000
SC205	16700	3000	20000
SC206	16700	3000	20000

APPENDIX 26: POTENTIAL APPLICATION RATES FOR THE SOLID AND LIQUID WASTES

Potential Application Rates for the Solid and Liquid Wastes.

Sump Number	Mud Vol m3	EC	SAR	Cl	Na	NH4&NO3	B	Oil		Cu	Zn	V	Cr
								10000	20000				
							(m3/ha)						
SC9A	189.0	1210.0	4450.0	866.0	784.00	2140000	133000	671.0	1340.0	25700	762	2900	8040
SC9BD	475.0	605.0	2610.0	433.0	697.00	515000	101000	250.0	500.0	30400	479	8770	17200
SC9C	358.0	61.6	1150.0	62.8	234.00	86700	49100	93.0	186.0	3890	1480	355	1120
SC10	648.0	658.0	555.0	14800.0	452.00	852000	83400	8510.0	17000.0	6710	4080	605	1720
SC11	178.0	1630.0	1010.0	5040.0	771.00	169000	16700	14600.0	29200.0	9330	6650	762	2690
SC12	77.5	119.0	1270.0	96.3	458.00	82300	32200	36700.0	73500.0	8210	5840	893	2330
SC13	258.0	607.0	194.0	446.0	331.00	20500	12800	61900.0	124000.0	18400	14300	1000	2000
SC14A	46.0	656.0	538.0	1550.0	546.00	271000	39000	9590.0	19200.0	10700	1420	367	997
SC14B	500.0	246.0	173.0	21100.0	3670.00	3480000	522000	32400.0	64700.0	49100	12400	2270	6810
SC15	461.0	2090.0	529.0	14100.0	829.00	341000	16700	56500.0	113000.0	25200	10200	1480	5220
SC16	210.0	1740.0	468.0	7840.0	463.00	649000	9980	16100.0	32100.0	12400	5210	744	2560
SC17	257.0	2110.0	659.0	4050.0	684.00	163000	7120	20200.0	40400.0	15200	7740	1180	3980
SC18	313.0	1130.0	959.0	1030.0	666.00	502000	41200	16900.0	33700.0	26800	8570	1390	3780
SC19A	2351.0	236.0	577.0	197.0	382.00	547000	53400	22700000	45500000	2e+07	4e+06	3e+06	1e+07
SC19B	880.0	161.0	596.0	180.0	278.00	876000	567000	797.0	1590.0	3990	1930	395	985
SC19C	402.0	227.0	716.0	348.0	485.00	1710000	247000	644.0	1290.0	2760	1310	382	911
SC21	590.0	622.0	857.0	1140.0	432.00	340000	9030	6260.0	12500.0	9590	3480	448	1700
SC24	1794.0	1630.0	1050.0	5840.0	777.00	194000	44700	20700.0	41400.0	18500	5940	1150	3300
SC25	1683.0	12300	446.0	4790.0	740.00	1460000	28700	73800.0	148000.0	55200	21600	3200	9490
SC26	784.0	1260.0	1590.0	2880.0	768.00	13700	24800	14700.0	29300.0	12100	5110	675	2180
SC27	920.0	1720.0	711.0	8090.0	487.00	2960	29700	28400.0	56800.0	29500	13300	1830	5650
SC28	839.0	669.0	799.0	272.0	402.00	239000	14700	16500.0	32900.0	25500	7750	1220	3530
SC29	1747.0	145.0	468.0	85.0	87.00	323000	19300	19600.0	39300.0	35200	18900	3720	8510
SC30A	540.0	3220.0	8180.0	8040.0	3320.00	12200000	165000	1060000.0	2120000.0	2010000	600000	151000	471000
SC30B	353.0	128.0	335.0	96.1	116.00	6530000	18200	7850000.0	15700000	5160000	868000	3e+06	1e+07
SC31	359.0	265.0	535.0	190.0	191.00	156000	54900	3410000.0	6830000.0	4e+07	2e+06	3e+06	3e+06
SC32	1765.0	998.0	808.0	3340.0	968.00	1030000	17000	14500.0	29100.0	32700	14500	2280	7230
SC33	249.0	1870.0	1570.0	7000.0	801.00	4630000	22100	47900.0	95800.0	30500	5120	1280	3120
SC34	4523.0	1190.0	838.0	17400.0	1250.00	254000	49700	99800.0	200000.0	43600	21300	3520	8330
SC35	5529.0	1110.0	686.0	6280.0	510.00	1680000	56500	38300.0	76600.0	16300	8100	1500	2580
SC36	728.0	94.8	999.0	76.9	411.00	304000	161000	20900.0	41900.0	11300	5030	727	2130
SC37	1058.0	7540.0	842.0	13500.0	1520.00	1850000	32500	63400.0	127000.0	29400	11300	1580	4820
SC38	926.0	7380.0	752.0	14100.0	1240.00	1210000	30200	53600.0	107000.0	20300	7350	1230	3530
SC39	1122.0	1010.0	1200.0	3350.0	542.00	563000	47400	78600.0	157000.0	25300	10800	1380	4100
SC40	5785.0	1080.0	567.0	2520.0	421.00	2370000	60300	29000.0	58000.0	56700	5840	3960	6690
SC41	1498.0	1210.0	838.0	2050.0	508.00	222000	48100	2860.0	5720.0	65900	12300	8310	24200
SC42	502.0	717.0	703.0	3680.0	486.00	216000	26500	60200.0	120000.0	19600	9170	1490	5790
SC43	895.0	730.0	527.0	1680.0	381.00	504000	9260	24200.0	48500.0	17400	11600	1300	4050
SC44	660.0	528.0	671.0	921.0	284.00	261000	7020	19200.0	38400.0	31800	23000	2490	10600
SC45	2330.0	761.0	579.0	1780.0	466.00	895000	26000	55400.0	111000.0	30800	11400	1830	3410
SC46	1290.0	670.0	1140.0	721.0	447.00	414000	75000	3800.0	7600.0	20800	9250	1350	4100
SC47	921.0	1100.0	672.0	3490.0	410.00	5250	42200	23100.0	46300.0	12000	5030	739	2270
SC48	1634.0	2150.0	1180.0	7730.0	1280.00	678000	46000	16300.0	32600.0	30600	16000	2670	7160
SC49	1576.0	597.0	423.0	1890.0	323.00	622000	19000	11200.0	22400.0	10800	8010	1340	3700
SC50	1710.0	811.0	897.0	5210.0	379.00	1330000	39900	35700.0	71400.0	17100	10900	1420	3600
SC53	730.0	561.0	1990.0	371.0	1100.00	2510000	90600	25100.0	50200.0	33100	11700	1430	5480
SC54	816.0	820.0	914.0	7460.0	588.00	517000	18800	12800.0	25700.0	10500	4770	542	2070
SC55	880.0	970.0	563.0	11700.0	482.00	159000	52900	14100.0	28200.0	12900	2880	729	2220
SC56A	535.0	80.3	219.0	43.2	117.00	1150000	99300	5880.0	11800.0	28300	5180	2380	3420
SC56B	115.0	90.9	435.0	56.6	200.00	819000	429000	8060.0	16100.0	22200	5310	1350	3920
SC56C	3.0	1140.0	6960.0	6.2	17.60	3910	12800	270.0	540.0	3260	665	194	456

(Continued). Potential Application Rates for the Solid and Liquid Wastes.

Sump Number	Ni	Cd	Pb
	------	(m3/ha)	------
SC9A	4100	25000	2660
SC9BD	6470	14900	5820
SC9C	637	4100	825
SC10	825	3490	998
SC11	1010	5360	1830
SC12	906	6050	5710
SC13	2550	28400	7160
SC14A	660	2510	1650
SC14B	3400	10400	19800
SC15	2300	7760	6670
SC16	1360	15700	3980
SC17	1740	8530	5920
SC18	2520	3170	2830
SC19A	1e+06	300000	2e+06
SC19B	493	3130	1060
SC19C	425	2120	1020
SC21	788	3910	2160
SC24	1590	9660	3330
SC25	4220	45100	16600
SC26	1070	7860	4360
SC27	2800	12300	11300
SC28	2170	55800	2740
SC29	4340	18400	8560
SC30A	188000	240000	324000
SC30B	829000	313000	1e+06
SC31	2e+06	302000	2e+06
SC32	2980	33600	26800
SC33	2770	2630	9880
SC34	5700	45200	13300
SC35	2520	5290	3820
SC36	1130	7760	5600
SC37	2770	5500	7240
SC38	1820	2770	4490
SC39	2400	12500	15700
SC40	5780	47500	25500
SC41	7350	180000	8840
SC42	1810	7080	7260
SC43	1500	29800	9380
SC44	3040	102000	25700
SC45	2550	11000	9200
SC46	1780	8070	10500
SC47	1140	17500	2770
SC48	3120	47500	8600
SC49	1270	14400	5110
SC50	1890	19200	9440
SC53	3490	7070	12100
SC54	1340	5390	4340
SC55	1450	22900	2850
SC56A	5560	110000	7790
SC56B	2750	12100	6680
SC56C	576	615	1080

(Continued). Potential Application Rates for the Solid and Liquid Wastes.

Sump	Mud Vol	EC	SAR	Cl	Na	NH4&NO3	B	------- Oil	------	Cu	Zn	V	Cr
Number	m3							10000	20000				
		----------	----------	----------	----------	----------	(m3/ha)	----------	----------	----------	----------	----------	----------
SC57	425.0	75.2	1130.0	49.1	166.00	61200	76100	95.7	191.0	2420	1220	452	1060
SC58	611.0	149.0	706.0	121.0	393.00	535000	77700	7860.0	15700.0	19100	4150	1050	3190
SC59	1305.0	569.0	1420.0	349.0	940.00	129000	413000	109000.0	218000.0	29900	15400	2040	6000
SC60	1014.0	533.0	329.0	1340.0	983.00	511000	129000	26800.0	53500.0	18300	6370	1550	4250
SC61	1730.0	199.0	518.0	213.0	325.00	65100	22300	530.0	1060.0	6450	3810	1240	3460
SC62AB	301.0	58.5	739.0	60.3	194.00	162000	6150	109.0	218.0	3440	933	283	922
SC62CD	939.0	853.0	1510.0	686.0	680.00	329000	49900	390.0	779.0	26800	8300	3820	11800
SC63	465.0	1930.0	656.0	4370.0	849.00	760000	14300	60200.0	120000.0	27800	20700	2930	9720
SC64	374.0	468.0	613.0	1620.0	247.00	276000	20900	50000.0	100000.0	35000	16500	2440	5710
SC65	55.0	1240.0	786.0	3660.0	484.00	473000	8950	15100.0	30200.0	20700	7050	674	2910
SC66	40.0	839.0	1110.0	917.0	612.00	961000	10400	38100.0	76200.0	16700	6040	715	2880
SC67	220.0	1670.0	462.0	5200.0	739.00	365000	7550	58200.0	116000.0	20200	13000	1940	6230
SC68	77.0	542.0	1240.0	2070.0	842.00	444000	45200	8120.0	16200.0	10600	2260	676	1850
SC69	665.0	2480.0	13700	441.0	836.00	825000	21900	465.0	930.0	19000	5040	2180	4860
SC70	292.0	11200	2540.0	7670.0	2660.00	1880000	114000	21100.0	42100.0	55300	14800	3980	9840
SC71A	135.0	51.6	2340.0	75.6	421.00	129000	41600	155.0	310.0	3090	673	341	847
SC71BC	143.0	2840.0	694.0	5200.0	2320.00	970000	127000	5720.0	11400.0	28100	6870	1920	5240
SC72A	113.0	3750.0	675.0	8450.0	1300.00	509000	61600	35100.0	70100.0	22200	6350	2380	4970
SC72BC	444.0	3600.0	490.0	83.1	416.00	130000	43300	420.0	841.0	3530	3410	683	2120
SC73	619.0	71100	1310.0	32900.0	735.00	1410	72000	7200.0	14400.0	6620	2840	614	1890
SC74	632.0	325.0	544.0	382.0	229.00	1960000	30500	57000.0	114000.0	19900	9300	1750	5220
SC75	143.0	1700.0	2500.0	6410.0	1200.00	1260000	37100	1410.0	2830.0	8190	4340	865	1970
SC76	480.0	1070.0	649.0	11500.0	664.00	1540	20900	10300.0	20500.0	13200	4560	965	3170
SC77	1436.0	460.0	3580.0	16200.0	1840.00	849000	129000	25500.0	50900.0	23100	7090	1740	4640
SC78	207.0	66.2	320.0	42.7	150.00	541000	73300	5860.0	11700.0	7700	1890	731	702
SC79	340.0	402.0	493.0	3780.0	374.00	653000	56100	421.0	843.0	5590	438	1680	2670
SC80	3396.0	778.0	362.0	5590.0	326.00	1170000	48300	10700.0	21400.0	19000	11700	1630	4550
SC81ABCD	2595.0	677.0	3410.0	467.0	1130.00	1580000	74300	294.0	588.0	19500	7940	1920	4810
SC82	3276.0	3940.0	552.0	20500.0	1160.00	969000	72100	23900.0	47900.0	33700	28100	4800	8050
SC83	1034.0	5150.0	1390.0	18100.0	1270.00	1560000	92200	41000.0	82000.0	42100	23700	4410	8760
SC84	840.0	1360.0	577.0	3390.0	778.00	5790	20400	13200.0	26300.0	35600	12700	1650	5730
SC85	529.0	1460.0	546.0	1380.0	816.00	526000	11500	6310.0	12600.0	71700	31500	4310	15200
SC86	481.0	3980.0	819.0	5650.0	1190.00	531000	21700	68000.0	136000.0	24700	13100	2170	6640
SC87	346.0	1030.0	714.0	3120.0	607.00	5020	17800	50700.0	101000.0	25800	7490	2090	2480
SC88	394.0	1620.0	1260.0	1160.0	625.00	379000	11900	3230.0	6460.0	16100	9960	890	3900
SC89	222.0	1820.0	445.0	2570.0	547.00	248000	8640	82300.0	165000.0	16300	2170	1920	6240
SC90	235.0	1630.0	389.0	2950.0	740.00	242000	8390	92200.0	184000.0	48500	20500	3120	9980
SC91	487.0	681.0	919.0	1520.0	420.00	2990	8480	6330.0	12700.0	9800	2430	484	1940
SC92	419.0	1800.0	393.0	2520.0	749.00	183000	7600	44600.0	89200.0	32100	5670	1750	5380
SC93	773.0	219.0	283.0	149.0	181.00	242000	21200	792.0	1580.0	4120	25200	6470	5530
SC94	727.0	1290.0	641.0	1150.0	637.00	555000	17800	55000.0	110000.0	31100	16500	2330	7490
SC95	3065.0	1150.0	344.0	6440.0	417.00	615000	73500	13900.0	27800.0	8590	814	1380	2950
SC96	222.0	817.0	495.0	1160.0	403.00	17400000	15400	7410000.0	14800000	4e+07	2e+06	3e+06	181000
SC97	877.0	801.0	771.0	7740.0	653.00	119000	85200	18300.0	36600.0	13100	8500	1350	3920
SC98	1328.0	90.7	570.0	35.0	194.00	207000	155000	19500.0	39100.0	8070	9040	1090	2770
SC99	549.0	732.0	2980.0	245.0	668.00	320000	61300	386.0	771.0	12700	6670	1660	4800
SC100	689.0	1260.0	417.0	1780.0	665.00	953000	26200	58100.0	116000.0	60000	15300	2610	8320
SC101	465.0	1110.0	847.0	1640.0	611.00	319000	23900	44300.0	88600.0	14500	7170	1070	3580
SC102	147.0	87.6	989.0	57.7	525.00	22200	171000	63600.0	127000.0	17300	8040	1520	4040
SC103	294.0	675.0	494.0	1450.0	382.00	970000	18500	15700.0	31500.0	12100	1870	580	2080
SC104	509.0	816.0	950.0	2610.0	644.00	351000	16700	18400.0	36800.0	19900	4220	1220	3860

(Continued). Potential Application Rates for the Solid and Liquid Wastes.

Sump Number	Ni ------	Cd (m3/ha)	Pb ------
SC57	438	2190	483
SC58	2190	21200	6100
SC59	3180	19200	10100
SC60	1860	11300	13500
SC61	1150	3990	1670
SC62AB	389	3830	1220
SC62CD	4310	16600	2450
SC63	3850	122000	17000
SC64	3430	11000	9460
SC65	1430	4450	6520
SC66	1460	8780	4520
SC67	2970	28500	8210
SC68	885	3880	2280
SC69	2260	9080	2900
SC70	5470	15300	5950
SC71A	397	5450	2290
SC71BC	2560	7290	2570
SC72A	2140	6300	2270
SC72BC	773	4130	1840
SC73	778	3780	312
SC74	2090	12800	6030
SC75	853	6230	1400
SC76	1320	5440	6690
SC77	2580	21800	9850
SC78	1300	3420	3250
SC79	954	23600	822
SC80	1990	13200	4100
SC81ABCD	2140	17800	1720
SC82	5100	156000	16300
SC83	4550	26800	7550
SC84	3280	8520	7130
SC85	7160	38900	17700
SC86	2720	23800	5100
SC87	3000	5990	13200
SC88	1640	4130	3550
SC89	1880	6540	5920
SC90	4780	22200	3980
SC91	1000	2240	4340
SC92	2780	6900	17800
SC93	5850	42800	15900
SC94	3370	6770	20500
SC95	972	7170	3560
SC96	2e+06	300000	2e+06
SC97	1510	10800	6860
SC98	894	5950	3110
SC99	1500	19800	4660
SC100	4930	76100	8360
SC101	1510	3780	4810
SC102	2110	58000	4510
SC103	1100	5470	4890
SC104	1930	6600	3240

(Concluded). Potential Application Rates for the Solid and Liquid Wastes.

Sump Number	Mud Vol m3	EC	SAR	Cl	Na	NH4&NO3	B	------- Oil ------ 10000	20000	Cu	Zn	V	Cr
		(m3/ha)											
SC105	575.0	174.0	784.0	132.0	396.00	147000	61100	20700.0	41300.0	18800	7690	1190	2980
SC106	583.0	156.0	759.0	105.0	340.00	232000	58300	58300.0	117000.0	24300	10000	1480	4930
SC107	1250.0	157.0	1800.0	97.5	575.00	56100	62500	2000.0	3990.0	9450	826	854	2690
SC108	2702.0	472.0	1330.0	317.0	528.00	279000	10700	276.0	551.0	7980	591	2960	6800
SC200	216.0	2500.0	2430.0	13100.0	747.00	25700000	132000	4810.0	9630.0	25400	1100	5900	10300
SC201	741.0	919.0	585.0	839.0	627.00	165000	86200	6110.0	12200.0	20600	7790	1200	4150
SC202	12210.0	980.0	959.0	6910.0	380.00	8750000	114000	1410.0	2820.0	8890	378	3220	5350
SC203	1646.0	2480.0	1340.0	4070.0	751.00	5040000	220000	90000.0	180000.0	31800	11200	4830	10900
SC204	1822.0	986.0	325.0	3790.0	515.00	195000	69900	1270000.0	2540000.0	4e+07	2e+06	3e+06	1e+07
SC205	92.0	97.1	1720.0	55.0	530.00	41000	124000	65900.0	132000.0	40500	15800	3490	9830
SC206	416.0	42.1	21.5	9.8	9.66	185000	520000	6260.0	12500.0	28900	10200	3960	1510

Sump Number	Ni	Cd	Pb
	------	(m3/ha)	------
SC105	784	3210	6180
SC106	2440	18800	8340
SC107	1120	3020	2510
SC108	2800	5980	5420
SC200	5520	5020	5230
SC201	1990	5370	5220
SC202	2740	3790	2620
SC203	3190	10700	5480
SC204	2e+06	300000	2e+06
SC205	3970	30500	12300
SC206	4520	31900	3590

APPENDIX 27: AREA REQUIRED FOR THE LAND APPLICATION OF THE SOLID AND LIQUID WASTES

Area Required for the Land Application of the Solid and Liquid Wastes.

Sump Number	Mud Vol m3	EC	SAR	Cl	Na	NH4&NO3	B	---- Oil ---		Cu	Zn	V	Cr	Ni	Cd	Pb
								10000	20000							
									(ha)							
SC9A	189.0	0.39	0.11	0.55	0.61	0.00	0.00	0.71	0.35	0.02	0.62	0.16	0.06	0.12	0.02	0.18
SC9BD	475.0	0.59	0.14	0.83	0.51	0.00	0.00	1.43	0.72	0.01	0.75	0.04	0.02	0.06	0.02	0.06
SC9C	358.0	3.07	0.16	3.01	0.81	0.00	0.00	2.03	1.02	0.05	0.13	0.53	0.17	0.30	0.05	0.23
SC10	648.0	0.99	1.17	0.04	1.43	0.00	0.01	0.08	0.04	0.10	0.16	1.07	0.38	0.79	0.19	0.65
SC11	178.0	0.11	0.18	0.04	0.23	0.00	0.01	0.01	0.01	0.02	0.03	0.23	0.07	0.18	0.03	0.10
SC12	77.5	0.65	0.06	0.80	0.17	0.00	0.00	0.00	0.00	0.01	0.01	0.09	0.03	0.09	0.01	0.01
SC13	258.0	0.43	1.33	0.58	0.78	0.01	0.02	0.00	0.00	0.01	0.02	0.26	0.13	0.10	0.01	0.04
SC14A	46.0	0.07	0.09	0.03	0.08	0.00	0.00	0.00	0.00	0.00	0.03	0.13	0.05	0.07	0.02	0.03
SC14B	500.0	2.04	2.89	0.02	0.14	0.00	0.00	0.02	0.01	0.01	0.04	0.22	0.07	0.15	0.05	0.03
SC15	461.0	0.22	0.87	0.03	0.56	0.00	0.03	0.01	0.00	0.02	0.05	0.31	0.09	0.20	0.06	0.07
SC16	210.0	0.12	0.45	0.03	0.45	0.00	0.02	0.01	0.01	0.02	0.04	0.28	0.08	0.15	0.01	0.05
SC17	257.0	0.12	0.39	0.06	0.38	0.00	0.04	0.01	0.01	0.02	0.03	0.22	0.06	0.15	0.03	0.04
SC18	313.0	0.28	0.33	0.30	0.47	0.00	0.01	0.02	0.01	0.01	0.04	0.23	0.08	0.12	0.10	0.11
SC19A	2351.0	9.98	4.07	12	6.16	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
SC19B	880.0	5.45	1.48	4.89	3.16	0.00	0.00	1.10	0.55	0.22	0.46	2.23	0.89	1.78	0.28	0.83
SC19C	402.0	1.77	0.56	1.16	0.83	0.00	0.00	0.62	0.31	0.15	0.31	1.05	0.44	0.95	0.19	0.39
SC21	590.0	0.95	0.69	0.52	1.36	0.00	0.07	0.09	0.05	0.06	0.17	1.32	0.35	0.75	0.15	0.27
SC24	1794.0	1.10	1.70	0.31	2.31	0.01	0.04	0.09	0.04	0.10	0.30	1.56	0.54	1.13	0.19	0.54
SC25	1683.0	0.14	3.77	0.35	2.27	0.00	0.06	0.02	0.01	0.03	0.08	0.53	0.18	0.40	0.04	0.10
SC26	784.0	0.62	0.49	0.27	1.02	0.06	0.03	0.05	0.03	0.06	0.15	1.16	0.36	0.73	0.10	0.18
SC27	920.0	0.53	1.29	0.11	1.89	0.31	0.03	0.03	0.02	0.03	0.07	0.50	0.16	0.33	0.07	0.08
SC28	839.0	1.25	1.05	3.08	2.09	0.00	0.06	0.05	0.03	0.03	0.11	0.69	0.24	0.39	0.02	0.31
SC29	1747.0	12	3.74	21	20	0.01	0.09	0.09	0.04	0.05	0.09	0.47	0.21	0.40	0.10	0.20
SC30A	540.0	0.17	0.07	0.07	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC30B	353.0	2.75	1.05	3.67	3.04	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC31	359.0	1.36	0.67	1.89	1.88	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC32	1765.0	1.77	2.18	0.53	1.82	0.00	0.10	0.12	0.06	0.05	0.12	0.78	0.24	0.59	0.05	0.07
SC33	249.0	0.13	0.16	0.04	0.31	0.00	0.01	0.01	0.00	0.01	0.05	0.20	0.08	0.09	0.09	0.03
SC34	4523.0	3.81	5.40	0.26	3.63	0.02	0.09	0.05	0.02	0.10	0.21	1.28	0.54	0.79	0.10	0.34
SC35	5529.0	4.96	8.06	0.88	11	0.00	0.10	0.14	0.07	0.34	0.68	3.70	2.15	2.19	1.05	1.45
SC36	728.0	7.68	0.73	9.47	1.77	0.00	0.00	0.03	0.02	0.06	0.15	1.00	0.34	0.64	0.09	0.13
SC37	1058.0	0.14	1.26	0.08	0.70	0.00	0.03	0.02	0.01	0.04	0.09	0.67	0.22	0.38	0.19	0.15
SC38	926.0	0.13	1.23	0.07	0.75	0.00	0.03	0.02	0.01	0.05	0.13	0.75	0.26	0.51	0.33	0.21
SC39	1122.0	1.11	0.93	0.34	2.07	0.00	0.02	0.01	0.01	0.04	0.10	0.81	0.27	0.47	0.09	0.07
SC40	5785.0	5.37	10	2.30	14	0.00	0.10	0.20	0.10	0.10	0.99	1.46	0.86	1.00	0.12	0.23
SC41	1498.0	1.23	1.79	0.73	2.95	0.01	0.03	0.52	0.26	0.02	0.12	0.18	0.06	0.20	0.01	0.17
SC42	502.0	0.70	0.71	0.14	1.03	0.00	0.02	0.01	0.00	0.03	0.05	0.34	0.09	0.28	0.07	0.07
SC43	895.0	1.23	1.70	0.53	2.35	0.00	0.10	0.04	0.02	0.05	0.08	0.69	0.22	0.60	0.03	0.10
SC44	660.0	1.25	0.98	0.72	2.32	0.00	0.09	0.03	0.02	0.02	0.03	0.27	0.06	0.22	0.01	0.03
SC45	2330.0	3.06	4.02	1.31	5.00	0.00	0.09	0.04	0.02	0.08	0.20	1.27	0.68	0.91	0.21	0.25
SC46	1290.0	1.93	1.13	1.79	2.88	0.00	0.02	0.34	0.17	0.06	0.14	0.96	0.31	0.73	0.16	0.12
SC47	921.0	0.84	1.37	0.26	2.25	0.18	0.02	0.04	0.02	0.08	0.18	1.25	0.41	0.81	0.05	0.33
SC48	1634.0	0.76	1.38	0.21	1.28	0.00	0.04	0.10	0.05	0.05	0.10	0.61	0.23	0.52	0.03	0.19
SC49	1576.0	2.64	3.73	0.84	4.88	0.00	0.08	0.14	0.07	0.15	0.20	1.18	0.43	1.24	0.11	0.31
SC50	1710.0	2.11	1.91	0.33	4.51	0.00	0.04	0.05	0.02	0.10	0.16	1.21	0.48	0.91	0.09	0.18
SC53	730.0	1.30	0.37	1.97	0.67	0.00	0.01	0.03	0.01	0.02	0.06	0.51	0.13	0.21	0.10	0.06
SC54	816.0	1.00	0.89	0.11	1.39	0.00	0.04	0.06	0.03	0.08	0.17	1.51	0.40	0.61	0.15	0.19
SC55	880.0	0.91	1.56	0.08	1.83	0.01	0.02	0.06	0.03	0.07	0.31	1.21	0.40	0.61	0.04	0.31
SC56A	535.0	1.43	0.53	2.66	0.98	0.00	0.00	0.02	0.01	0.00	0.02	0.05	0.03	0.02	0.00	0.01

(Continued). Area Required for the Land Application of the Solid and Liquid Wastes.

Sump Number	Mud Vol m3	EC	SAR	Cl	Na	NH4&NO3	B	---- Oil --- 10000	20000	Cu	Zn	V	Cr	Ni	Cd	Pb
								(ha)								
SC56B	115.0	5.89	1.23	9.46	2.68	0.00	0.00	0.07	0.03	0.02	0.10	0.40	0.14	0.20	0.04	0.08
SC56C	3.0	0.00	0.00	0.49	0.17	0.00	0.00	0.01	0.01	0.00	0.00	0.02	0.01	0.01	0.00	0.00
SC57	425.0	5.65	0.38	8.66	2.55	0.01	0.01	4.44	2.22	0.18	0.35	0.94	0.40	0.97	0.19	0.88
SC58	611.0	4.10	0.87	5.03	1.56	0.00	0.01	0.08	0.04	0.03	0.15	0.58	0.19	0.28	0.03	0.10
SC59	1305.0	2.29	0.92	3.74	1.39	0.01	0.00	0.01	0.01	0.04	0.08	0.64	0.22	0.41	0.07	0.13
SC60	1014.0	1.90	3.09	0.76	1.03	0.00	0.01	0.04	0.02	0.06	0.16	0.66	0.24	0.55	0.09	0.08
SC61	1730.0	8.68	3.34	8.11	5.32	0.03	0.08	3.26	1.63	0.27	0.45	1.39	0.50	1.50	0.43	1.03
SC62AB	301.0	5.15	0.41	4.99	1.55	0.00	0.05	2.76	1.38	0.09	0.32	1.06	0.33	0.77	0.08	0.25
SC62CD	939.0	1.10	0.62	1.37	1.38	0.00	0.02	2.41	1.20	0.04	0.11	0.25	0.08	0.22	0.06	0.38
SC63	465.0	0.24	0.71	0.11	0.55	0.00	0.03	0.01	0.00	0.02	0.02	0.16	0.05	0.12	0.00	0.03
SC64	374.0	0.80	0.61	0.23	1.52	0.00	0.02	0.01	0.00	0.01	0.02	0.15	0.07	0.11	0.03	0.04
SC65	55.0	0.04	0.07	0.02	0.11	0.00	0.01	0.00	0.00	0.00	0.01	0.08	0.02	0.04	0.01	0.01
SC66	40.0	0.05	0.04	0.04	0.07	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.01	0.03	0.00	0.01
SC67	220.0	0.13	0.48	0.04	0.30	0.00	0.03	0.00	0.00	0.01	0.02	0.11	0.04	0.07	0.01	0.03
SC68	77.0	0.14	0.06	0.04	0.09	0.00	0.00	0.01	0.00	0.01	0.03	0.11	0.04	0.09	0.02	0.03
SC69	665.0	0.27	0.05	1.51	0.80	0.00	0.03	1.43	0.72	0.04	0.13	0.31	0.14	0.29	0.07	0.23
SC70	292.0	0.03	0.12	0.04	0.11	0.00	0.00	0.01	0.01	0.01	0.02	0.07	0.03	0.05	0.02	0.05
SC71A	135.0	2.77	0.06	1.89	0.34	0.00	0.00	0.92	0.46	0.05	0.21	0.42	0.17	0.36	0.03	0.06
SC71BC	143.0	0.05	0.20	0.03	0.06	0.00	0.00	0.02	0.01	0.00	0.02	0.07	0.03	0.05	0.02	0.05
SC72A	113.0	0.03	0.17	0.01	0.09	0.00	0.00	0.00	0.00	0.01	0.02	0.05	0.02	0.05	0.02	0.05
SC72BC	444.0	0.12	0.91	5.35	1.07	0.00	0.01	1.06	0.53	0.13	0.13	0.65	0.21	0.57	0.11	0.24
SC73	619.0	0.01	0.47	0.02	0.84	0.44	0.01	0.09	0.04	0.09	0.22	1.01	0.33	0.80	0.16	1.99
SC74	632.0	1.95	1.16	1.65	2.76	0.00	0.02	0.01	0.01	0.03	0.07	0.36	0.12	0.30	0.05	0.11
SC75	143.0	0.08	0.06	0.02	0.12	0.00	0.00	0.10	0.05	0.02	0.03	0.17	0.07	0.17	0.02	0.10
SC76	480.0	0.45	0.74	0.04	0.72	0.31	0.02	0.05	0.02	0.04	0.11	0.50	0.15	0.36	0.09	0.07
SC77	1436.0	3.12	0.40	0.09	0.78	0.00	0.01	0.06	0.03	0.06	0.20	0.82	0.31	0.56	0.07	0.15
SC78	207.0	3.13	0.65	4.85	1.38	0.00	0.00	0.04	0.02	0.03	0.11	0.28	0.30	0.16	0.06	0.06
SC79	340.0	0.85	0.69	0.09	0.91	0.00	0.01	0.81	0.40	0.06	0.78	0.20	0.13	0.36	0.01	0.41
SC80	3396.0	4.36	9.38	0.61	10	0.00	0.07	0.32	0.16	0.18	0.29	2.08	0.75	1.71	0.26	0.83
SC81ABCD	2595.0	3.83	0.76	5.55	2.30	0.00	0.03	8.83	4.41	0.13	0.33	1.35	0.54	1.21	0.15	1.51
SC82	3276.0	0.83	5.93	0.16	2.82	0.00	0.05	0.14	0.07	0.10	0.12	0.68	0.41	0.64	0.02	0.20
SC83	1034.0	0.20	0.75	0.06	0.82	0.00	0.01	0.03	0.01	0.02	0.04	0.24	0.12	0.23	0.04	0.14
SC84	840.0	0.62	1.45	0.25	1.08	0.15	0.04	0.06	0.03	0.02	0.07	0.51	0.15	0.26	0.10	0.12
SC85	529.0	0.36	0.97	0.38	0.65	0.00	0.05	0.08	0.04	0.01	0.02	0.12	0.03	0.07	0.01	0.03
SC86	481.0	0.12	0.59	0.09	0.40	0.00	0.02	0.01	0.00	0.02	0.04	0.22	0.07	0.18	0.02	0.09
SC87	346.0	0.34	0.49	0.11	0.57	0.07	0.02	0.01	0.00	0.01	0.05	0.17	0.14	0.12	0.06	0.03
SC88	394.0	0.24	0.31	0.34	0.63	0.00	0.03	0.12	0.06	0.02	0.04	0.44	0.10	0.24	0.10	0.11
SC89	222.0	0.12	0.50	0.09	0.41	0.00	0.03	0.00	0.00	0.01	0.10	0.12	0.04	0.12	0.03	0.04
SC90	235.0	0.14	0.61	0.08	0.32	0.00	0.03	0.00	0.00	0.00	0.01	0.08	0.02	0.05	0.01	0.06
SC91	487.0	0.72	0.53	0.32	1.16	0.16	0.06	0.08	0.04	0.05	0.20	1.01	0.25	0.49	0.22	0.11
SC92	419.0	0.23	1.07	0.17	0.56	0.00	0.06	0.01	0.00	0.01	0.07	0.24	0.08	0.15	0.06	0.02
SC93	773.0	3.52	2.73	5.19	4.28	0.00	0.04	0.98	0.49	0.19	0.03	0.12	0.14	0.13	0.02	0.05
SC94	727.0	0.56	1.13	0.63	1.14	0.00	0.04	0.01	0.01	0.02	0.04	0.31	0.10	0.22	0.11	0.04
SC95	3065.0	2.67	8.90	0.48	7.34	0.00	0.04	0.22	0.11	0.36	3.77	2.22	1.04	3.15	0.43	0.86
SC96	222.0	0.27	0.45	0.19	0.55	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SC97	877.0	1.09	1.14	0.11	1.34	0.01	0.01	0.05	0.02	0.07	0.10	0.65	0.22	0.58	0.08	0.13
SC98	1328.0	15	2.33	38	6.83	0.01	0.01	0.07	0.03	0.17	0.15	1.21	0.48	1.49	0.22	0.43
SC99	549.0	0.75	0.18	2.25	0.82	0.00	0.01	1.42	0.71	0.04	0.08	0.33	0.11	0.37	0.03	0.12

(Concluded). Area Required for the Land Application of the Solid and Liquid Wastes.

Sump Number	Mud Vol m3	EC	SAR	Cl	Na	NH4&NO3	B	---- Oil --- 10000	20000	Cu	Zn	V	Cr	Ni	Cd	Pb
		----------	----------	----------	----------	----------	----------	----------	(ha)	----------	----------	----------	----------	----------	----------	----------
SC100	689.0	0.55	1.65	0.39	1.04	0.00	0.03	0.01	0.01	0.01	0.04	0.26	0.08	0.14	0.01	0.08
SC101	465.0	0.42	0.55	0.28	0.76	0.00	0.02	0.01	0.01	0.03	0.06	0.43	0.13	0.31	0.12	0.10
SC102	147.0	1.68	0.15	2.55	0.28	0.01	0.00	0.00	0.00	0.01	0.02	0.10	0.04	0.07	0.00	0.03
SC103	294.0	0.44	0.60	0.20	0.77	0.00	0.02	0.02	0.01	0.02	0.16	0.51	0.14	0.27	0.05	0.06
SC104	509.0	0.62	0.54	0.20	0.79	0.00	0.03	0.03	0.01	0.03	0.12	0.42	0.13	0.26	0.08	0.16
SC105	575.0	3.30	0.73	4.35	1.45	0.00	0.01	0.03	0.01	0.03	0.07	0.48	0.19	0.73	0.18	0.09
SC106	583.0	3.73	0.77	5.54	1.72	0.00	0.01	0.01	0.01	0.02	0.06	0.40	0.12	0.24	0.03	0.07
SC107	1250.0	7.98	0.69	13	2.17	0.02	0.02	0.63	0.31	0.13	1.51	1.46	0.47	1.11	0.41	0.50
SC108	2702.0	5.73	2.04	8.53	5.12	0.01	0.25	9.80	4.90	0.34	4.57	0.91	0.40	0.96	0.45	0.50
SC200	216.0	0.09	0.09	0.02	0.29	0.00	0.00	0.04	0.02	0.01	0.20	0.04	0.02	0.04	0.04	0.04
SC201	741.0	0.81	1.27	0.88	1.18	0.00	0.01	0.12	0.06	0.04	0.10	0.62	0.18	0.37	0.14	0.14
SC202	12210.0	13	13	1.77	32	0.00	0.11	8.67	4.33	1.37	32	3.79	2.28	4.45	3.22	4.66
SC203	1646.0	0.66	1.23	0.41	2.19	0.00	0.01	0.02	0.01	0.05	0.15	0.34	0.15	0.52	0.15	0.30
SC204	1822.0	1.85	5.60	0.48	3.54	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
SC205	92.0	0.95	0.05	1.67	0.17	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.01	0.02	0.00	0.01
SC206	416.0	9.89	19	42	43	0.00	0.00	0.07	0.03	0.01	0.04	0.11	0.28	0.09	0.01	0.12

APPENDIX 28: LIMITING ANALYTES REQUIRING >1 HA FOR APPLICATION OF THE SOLID AND LIQUID WASTES

Limiting Analytes Requiring >1 ha for Application of the Solid and Liquid Wastes.

Sump	Mud Vol	EC	SAR	Cl	Na	NH4&NO3	B	---- Oil ---		Cu	Zn	V	Cr	Ni	Cd	Pb
Number	m3							10000	20000							
									(ha)							
SC9A	189.0															
SC9BD	475.0							1.43								
SC9C	358.0	3.07		3.01				2.03	1.02							
SC10	648.0		1.17		1.43							1.07				
SC11	178.0															
SC12	77.5															
SC13	258.0		1.33													
SC14A	46.0															
SC14B	500.0	2.04	2.89													
SC15	461.0															
SC16	210.0															
SC17	257.0															
SC18	313.0															
SC19A	2351.0	9.98	4.07	11.90	6.16											
SC19B	880.0	5.45	1.48	4.89	3.16			1.10				2.23		1.78		
SC19C	402.0	1.77		1.16								1.05				
SC21	590.0				1.36							1.32				
SC24	1794.0	1.10	1.70		2.31							1.56		1.13		
SC25	1683.0		3.77		2.27											
SC26	784.0				1.02							1.16				
SC27	920.0		1.29		1.89											
SC28	839.0	1.25	1.05	3.08	2.09											
SC29	1747.0	12.00	3.74	20.60	20.10											
SC30A	540.0															
SC30B	353.0	2.75	1.05	3.67	3.04											
SC31	359.0	1.36		1.89	1.88											
SC32	1765.0	1.77	2.18		1.82											
SC33	249.0															
SC34	4523.0	3.81	5.40		3.63							1.28				
SC35	5529.0	4.96	8.06		10.80							3.70	2.15	2.19	1.05	1.45
SC36	728.0	7.68		9.47	1.77							1.00				
SC37	1058.0		1.26													
SC38	926.0		1.23													
SC39	1122.0	1.11			2.07											
SC40	5785.0	5.37	10.20	2.30	13.70							1.46		1.00		
SC41	1498.0	1.23	1.79		2.95											
SC42	502.0				1.03											
SC43	895.0	1.23	1.70		2.35											
SC44	660.0	1.25			2.32											
SC45	2330.0	3.06	4.02	1.31	5.00							1.27				
SC46	1290.0	1.93	1.13	1.79	2.88											
SC47	921.0		1.37		2.25							1.25				
SC48	1634.0		1.38		1.28											
SC49	1576.0	2.64	3.73		4.88							1.18		1.24		
SC50	1710.0	2.11	1.91		4.51							1.21				
SC53	730.0	1.30		1.97												
SC54	816.0				1.39							1.51				
SC55	880.0		1.56		1.83							1.21				
SC56A	535.0	1.43		2.66												
SC56B	115.0	5.89	1.23	9.46	2.68											
SC56C	3.0															

(Continued). Limiting Analytes Requiring >1 ha for Application of the Solid and Liquid Wastes.

Sump Number	Mud Vol m3	EC	SAR	Cl	Na	NH4&NO3	B	---- Oil ---		Cu	Zn	V	Cr	Ni	Cd	Pb
								10000	20000							
									(ha)							
SC57	425.0	5.65		8.66	2.55			4.44	2.22							
SC58	611.0	4.10		5.03	1.56											
SC59	1305.0	2.29		3.74	1.39											
SC60	1014.0	1.90	3.09		1.03											
SC61	1730.0	8.68	3.34	8.11	5.32			3.26	1.63			1.39		1.50		1.03
SC62AB	301.0	5.15		4.99	1.55			2.76	1.38			1.06				
SC62CD	939.0	1.10		1.37	1.38			2.41	1.20							
SC63	465.0															
SC64	374.0				1.52											
SC65	55.0															
SC66	40.0															
SC67	220.0															
SC68	77.0															
SC69	665.0			1.51				1.43								
SC70	292.0															
SC71A	135.0	2.77		1.89												
SC71BC	143.0															
SC72A	113.0															
SC72BC	444.0			5.35	1.07			1.06								
SC73	619.0											1.01				1.99
SC74	632.0	1.95	1.16	1.65	2.76											
SC75	143.0															
SC76	480.0															
SC77	1436.0	3.12														
SC78	207.0	3.13		4.85	1.38											
SC79	340.0															
SC80	3396.0	4.36	9.38		10.40							2.08		1.71		
SC81ABCD	2595.0	3.83		5.55	2.30			8.83	4.41			1.35		1.21		1.51
SC82	3276.0		5.93		2.82											
SC83	1034.0															
SC84	840.0		1.45		1.08											
SC85	529.0															
SC86	481.0															
SC87	346.0															
SC88	394.0															
SC89	222.0															
SC90	235.0															
SC91	487.0				1.16							1.01				
SC92	419.0		1.07													
SC93	773.0	3.52	2.73	5.19	4.28											
SC94	727.0		1.13		1.14											
SC95	3065.0	2.67	8.90		7.34						3.77	2.22	1.04	3.15		
SC96	222.0															
SC97	877.0	1.09	1.14		1.34											
SC98	1328.0	14.60	2.33	38.00	6.83							1.21		1.49		
SC99	549.0			2.25				1.42								
SC100	689.0		1.65		1.04											
SC101	465.0															
SC102	147.0	1.68		2.55												
SC103	294.0															

(Concluded). Limiting Analytes Requiring >1 ha for Application of the Solid and Liquid Wastes.

Sump	Mud Vol	EC	SAR	Cl	Na	NH4&NO3	B	---- Oil ---		Cu	Zn	V	Cr	Ni	Cd	Pb
Number	m3							10000	20000							
									(ha)							
SC104	509.0															
SC105	575.0	3.30		4.35	1.45											
SC106	583.0	3.73		5.54	1.72											
SC107	1250.0	7.98		12.80	2.17						1.51	1.46		1.11		
SC108	2702.0	5.73	2.04	8.53	5.12			9.80	4.90		4.57					
SC200	216.0															
SC201	741.0		1.27		1.18											
SC202	12210.0	12.50	12.70	1.77	32.10			8.67	4.33	1.37	32.30	3.79	2.28	4.45	3.22	4.66
SC203	1646.0		1.23		2.19											
SC204	1822.0	1.85	5.60		3.54											
SC205	92.0			1.67												
SC206	416.0	9.89	19.30	42.40	43.10											

RECLAMATION RESEARCH REPORTS

1. **RRTAC 79-2: Proceedings: Workshop on Native Shrubs in Reclamation. P.F. Ziemkiewicz, C.A. Dermott and H.P. Sims (Editors). 104 pp. No longer available.**

The Workshop was organized as the first step in developing a Native Shrub reclamation research program. The Workshop provided a forum for the exchange of information and experiences on three topics: propagation; outplanting; and, species selection. Seven papers and the results of three discussion groups are presented.

2. **RRTAC 80-1: Test Plot Establishment: Native Grasses for Reclamation. R.S. Sadasivaiah and J. Weijer. 19 pp. No longer available.**

The report details the species used at three test plots in Alberta's Eastern Slopes (one at Caw Creek Ridge and two at Cadomin). Site preparation, experimental design, and planting method are also described.

3. **RRTAC 80-2: Alberta's Reclamation Research Program - 1979. Reclamation Research Technical Advisory Committee. 22 pp. No longer available.**

This report describes the expenditure of $1,190,006 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

4. **RRTAC 80-3: The Role of Organic Compounds in Salinization of Plains Coal Mining Sites. N.S.C. Cameron et al. 46 pp. No longer available.**

This is a literature review of the chemistry of sodic mine spoil and the changes expected to occur in groundwater.

5. **RRTAC 80-4: Proceedings: Workshop on Reconstruction of Forest Soils in Reclamation. P.F. Ziemkiewicz, S.K. Takyi and H.F. Regier (Editors). 160 pp. $10.00**

Experts in the field of forestry and forest soils report on research relevant to forest soil reconstruction and discuss the most effective means of restoring forestry capability of mined lands.

6. **RRTAC 80-5: Manual of Plant Species Suitability for Reclamation in Alberta. L.E. Watson, R.W. Parker and D.F. Polster. 2 vols, 541 pp. No longer available; replaced by RRTAC 89-4.**

Forty-three grass, fourteen forb, and thirty-four shrub and tree species are assessed in terms of their suitability for use in reclamation. Range maps, growth habit, propagation, tolerance, and availability information are provided.

7. **RRTAC 81-1: The Alberta Government's Reclamation Research Program - 1980. Reclamation Research Technical Advisory Committee. 25 pp. No longer available.**

This report describes the expenditure of $1,455,680 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

8. **RRTAC 81-2: 1980 Survey of Reclamation Activities in Alberta. D.G. Walker and R.L. Rothwell. 76 pp. $10.00**

This survey is an update of a report prepared in 1976 on reclamation activities in Alberta, and includes research and operational reclamation, locations, personnel, etc.

9. **RRTAC 81-3: Proceedings: Workshop on Coal Ash and Reclamation. P.F. Ziemkiewicz, R. Stein, R. Leitch and G. Lutwick (Editors). 253 pp. $10.00**

Presents nine technical papers on the chemical, physical, and engineering properties of Alberta fly and bottom ashes, revegetation of ash disposal sites, and use of ash as a soil amendment. Workshop discussions and summaries are also included.

10. **RRTAC 82-1: Land Surface Reclamation: An International Bibliography. H.P. Sims and C.B. Powter. 2 vols, 292 pp. $10.00**

Literature to 1980 pertinent to reclamation in Alberta is listed in Vol. 1 and is also on the University of Alberta computing system (in a SPIRES database called RECLAIM). Vol. 2 comprises the keyword index and computer access manual.

11. **RRTAC 82-2: A Bibliography of Baseline Studies in Alberta: Soils, Geology, Hydrology and Groundwater. C.B. Powter and H.P. Sims. 97 pp. $5.00**

This bibliography provides baseline information for persons involved in reclamation research or in the preparation of environmental impact assessments. Materials, up to date as of December 1981, are available in the Alberta Environment Library.

12. **RRTAC 82-3: The Alberta Government's Reclamation Research Program - 1981. Reclamation Research Technical Advisory Committee. 22 pp. No longer available.**

This report describes the expenditure of $1,499,525 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

13. **RRTAC 83-1: Soil Reconstruction Design for Reclamation of Oil Sand Tailings. Monenco Consultants Ltd. 185 pp. No longer available**

Volumes of peat and clay required to amend oil sand tailings were estimated based on existing literature. Separate soil prescriptions were made for spruce, jack pine, and herbaceous cover types. The estimates form the basis of field trials.

14. **RRTAC 83-2: The Alberta Government's Reclamation Research Program - 1982. Reclamation Research Technical Advisory Committee. 25 pp. No longer available.**

This report describes the expenditure of $1,536,142 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

15. **RRTAC 83-3: Evaluation of Pipeline Reclamation Practices on Agricultural Lands in Alberta. Hardy Associates (1978) Ltd. 205 pp. No longer available.**

Available information on pipeline reclamation practices was reviewed. A field survey was then conducted to determine the effects of pipe size, age, soil type, construction method, etc. on resulting crop production.

16. **RRTAC 83-4: Proceedings: Effects of Coal Mining on Eastern Slopes Hydrology. P.F. Ziemkiewicz (Editor). 123 pp. $10.00**

Technical papers are presented dealing with the impacts of mining on mountain watersheds, their flow characteristics, and resulting water quality. Mitigative measures and priorities were also discussed.

17. RRTAC 83-5: **Woody Plant Establishment and Management for Oil Sands Mine Reclamation. Techman Engineering Ltd. 124 pp. No longer available.**

This is a review and analysis of information on planting stock quality, rearing techniques, site preparation, planting, and procedures necessary to ensure survival of trees and shrubs in oil sand reclamation.

18. RRTAC 84-1: **Land Surface Reclamation: A Review of the International Literature. H.P. Sims, C.B. Powter and J.A. Campbell. 2 vols, 1549 pp. $20.00**

Nearly all topics of interest to reclamationists including mining methods, soil amendments, revegetation, propagation and toxic materials are reviewed in light of the international literature.

19. RRTAC 84-2: **Propagation Study: Use of Trees and Shrubs for Oil Sand Reclamation. Techman Engineering Ltd. 58 pp. $10.00**

This report evaluates and summarizes all available published and unpublished information on large-scale propagation methods for shrubs and trees to be used in oil sand reclamation.

20. RRTAC 84-3: **Reclamation Research Annual Report - 1983. P.F. Ziemkiewicz. 42 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

21. RRTAC 84-4: **Soil Microbiology in Land Reclamation. D. Parkinson, R.M. Danielson, C. Griffiths, S. Visser and J.C. Zak. 2 vols, 676 pp. $10.00**

This is a collection of five reports dealing with re-establishment of fungal decomposers and mycorrhizal symbionts in various amended spoil types.

22. RRTAC 85-1: **Proceedings: Revegetation Methods for Alberta's Mountains and Foothills. P.F. Ziemkiewicz (Editor). 416 pp. No longer available.**

Results of long-term experiments and field experience on species selection, fertilization, reforestation, topsoiling, shrub propagation and establishment are presented.

23. RRTAC 85-2: **Reclamation Research Annual Report - 1984. P.F. Ziemkiewicz. 29 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

24. RRTAC 86-1: **A Critical Analysis of Settling Pond Design and Alternative Technologies. A. Somani. 372 pp. $10.00**

The report examines the critical issue of settling pond design, and sizing and alternative technologies. The study was co-funded with The Coal Association of Canada.

25. RRTAC 86-2: **Characterization and Variability of Soil Reconstructed after Surface Mining in Central Alberta. T.M. Macyk. 146 pp. No longer available.**

Reconstructed soils representing different materials handling and replacement techniques were characterized, and variability in chemical and physical properties was assessed. The data obtained indicate that reconstructed soil properties are determined largely by parent material characteristics and further tempered by materials handling procedures. Mining tends to create a relatively homogeneous soil landscape in contrast to the mixture of diverse soils found before mining.

26. **RRTAC 86-3: Generalized Procedures for Assessing Post-Mining Groundwater Supply Potential in the Plains of Alberta - Plains Hydrology and Reclamation Project. M.R. Trudell and S.R. Moran. 30 pp. $5.00**

In the Plains region of Alberta, the surface mining of coal generally occurs in rural, agricultural areas in which domestic water supply requirements are met almost entirely by groundwater. Consequently, an important aspect of the capability of reclaimed lands to satisfy the needs of a residential component is the post-mining availability of groundwater. This report proposes a sequence of steps or procedures to identify and characterize potential post-mining aquifers.

27. **RRTAC 86-4: Geology of the Battle River Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze, R. Li, M. Fenton and S.R. Moran. 86 pp. $10.00**

This report summarizes the geological setting of the Battle River study site. It is designed to provide a general understanding of geological conditions adequate to establish a framework for hydrogeological and general reclamation studies. The report is not intended to be a detailed synthesis such as would be required for mine planning purposes.

28. **RRTAC 86-5: Chemical and Mineralogical Properties of Overburden: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze. 71 pp. $10.00**

This report describes the physical and mineralogical properties of overburden materials in an effort to identify individual beds within the bedrock overburden that might be significantly different in terms of reclamation potential.

29. **RRTAC 86-6: Post-Mining Groundwater Supply at the Battle River Site: Plains Hydrology and Reclamation Project. M.R. Trudell, G.J. Sterenberg and S.R. Moran. 49 pp. $5.00**

The report deals with the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations. The study area is in the Battle River Mining area in east-central Alberta.

30. **RRTAC 86-7: Post-Mining Groundwater Supply at the Highvale Site: Plains Hydrology and Reclamation Project. M.R. Trudell. 25 pp. $5.00**

This report evaluates the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations. The study area is the Highvale mining area in west-central Alberta.

31. **RRTAC 86-8: Reclamation Research Annual Report - 1985. P.F. Ziemkiewicz. 54 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

32. **RRTAC 86-9: Wildlife Habitat Requirements and Reclamation Techniques for the Mountains and Foothills of Alberta. J.E. Green, R.E. Salter and D.G. Walker. 285 pp. No longer available.**

This report presents a review of relevant North American literature on wildlife habitats in mountain and foothills biomes, reclamation techniques, potential problems in wildlife habitat reclamation, and potential habitat assessment methodologies. Four biomes (Alpine, Subalpine, Montane, and Boreal Uplands) and 10 key wildlife species (snowshoe hare, beaver, muskrat, elk, moose, caribou, mountain goat, bighorn sheep, spruce grouse, and white-tailed ptarmigan) are discussed. The study was co-funded with The Coal Association of Canada.

33. **RRTAC 87-1: Disposal of Drilling Wastes. L.A. Leskiw, E. Reinl-Dwyer, T.L. Dabrowski, B.J. Rutherford and H. Hamilton. 210 pp. No longer available.**

Current drilling waste disposal practices are reviewed and criteria in Alberta guidelines are assessed. The report also identifies research needs and indicates mitigation measures. A manual provides a decision-making flowchart to assist in selecting methods of environmentally safe waste disposal.

34. **RRTAC 87-2: Minesoil and Landscape Reclamation of the Coal Mines in Alberta's Mountains and Foothills. A.W. Fedkenheuer, L.J. Knapik and D.G. Walker. 174 pp. No longer available.**

This report reviews current reclamation practices with regard to site and soil reconstruction and re-establishment of biological productivity. It also identifies research needs in the Mountain-Foothills area. The study was co-funded with The Coal Association of Canada.

35. **RRTAC 87-3: Gel and Saline Drilling Wastes in Alberta: Workshop Proceedings. D.A. Lloyd (Compiler). 218 pp. No longer available.**

Technical papers were presented which describe: mud systems used and their purpose; industrial constraints; government regulations, procedures and concerns; environmental considerations in waste disposal; and toxic constituents of drilling wastes. Answers to a questionnaire distributed to participants are included in an appendix.

36. **RRTAC 87-4: Reclamation Research Annual Report - 1986. 50 pp. No longer available.**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

37. **RRTAC 87-5: Review of the Scientific Basis of Water Quality Criteria for the East Slope Foothills of Alberta. Beak Associates Consulting Ltd. 46 pp. $10.00**

The report reviews existing Alberta guidelines to assess the quality of water drained from coal mine sites in the East Slope Foothills of Alberta. World literature was reviewed within the context of the East Slopes environment and current mining operations. The ability of coal mine operators to meet the various guidelines is discussed. The study was co-funded with The Coal Association of Canada.

38. **RRTAC 87-6: Assessing Design Flows and Sediment Discharge on the Eastern Slopes. Hydrocon Engineering (Continental) Ltd. and Monenco Consultants Ltd. 97 pp. $10.00**

The report provides an evaluation of current methodologies used to determine sediment yields due to rainfall events in well-defined areas. Models are available in Alberta to evaluate water and sediment discharge in a post-mining situation. SEDIMOT II (Sedimentology Disturbed Modelling Techniques) is a single storm model that was developed specifically for the design of sediment control structures in watersheds disturbed by surface mining and is well suited to Alberta conditions. The study was co-funded with The Coal Association of Canada.

39. **RRTAC 87-7: The Use of Bottom Ash as an Amendment to Sodic Spoil. S. Fullerton. 83 pp. No longer available.**

The report details the use of bottom ash as an amendment to sodic coal mine spoil. Several rates and methods of application of bottom ash to sodic spoil were tested to determine which was the best at reducing the effects of excess sodium and promoting crop growth. Field trials were set up near the Vesta mine in East Central Alberta using ash readily available from a nearby coal-fired thermal generating station. The research indicated that bottom ash incorporated to a depth of 30 cm using a subsoiler provided the best results.

40. **RRTAC 87-8: Waste Dump Design for Erosion Control. R.G. Chopiuk and S.E. Thornton. 45 pp. $5.00**

This report describes a study to evaluate the potential influence of erosion from reclaimed waste dumps on downslope environments such as streams and rivers. Sites were selected from coal mines in Alberta's mountains and foothills, and included resloped dumps of different configurations and ages, and having different vegetation covers. The study concluded that the average annual amount of surface erosion is minimal. As expected, erosion was greatest on slopes which were newly regraded. Slopes with dense grass cover showed no signs of erosion. Generally, the amount of erosion decreased with time, as a result of initial loss of fine particles, the formation of a weathered surface, and increased vegetative cover.

41. **RRTAC 87-9: Hydrogeology and Groundwater Chemistry of the Battle River Mining Area. M.R. Trudell, R.L. Faught and S.R. Moran. 97 pp. No longer available.**

This report describes the premining geologic conditions in the Battle River coal mining area including the geology as well as the groundwater flow patterns, and the groundwater quality of a sequence of several water-bearing formations extending from the surface to a depth of about 100 metres.

42. **RRTAC 87-10: Soil Survey of the Plains Hydrology and Reclamation Project - Battle River Project Area. T.M. Macyk and A.H. MacLean. 62 pp. plus 8 maps. $10.00**

The report evaluates the capability of post-mining landscapes and assesses the changes in capability as a result of mining, in the Battle River mining area. Detailed soils information is provided in the report for lands adjacent to areas already mined as well as for lands that are destined to be mined. Characterization of the reconstructed soils in the reclaimed areas is also provided. Data were collected from 1979 to 1985. Eight maps supplement the report.

43. **RRTAC 87-11: Geology of the Highvale Study Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze. 78 pp. $10.00**

The report is one of a series that describes the geology, soils and groundwater conditions at the Highvale Coal Mine study site. The purpose of the study was to establish a summary of site geology to a level of detail necessary to provide a framework for studies of hydrogeology and reclamation.

44. **RRTAC 87-12: Premining Groundwater Conditions at the Highvale Site. M.R. Trudell and R. Faught. 83 pp. $10.00**

This report presents a detailed discussion of the premining flow patterns, hydraulic properties, and isotopic and hydrochemical characteristics of five layers within the Paskapoo Geological Formation, the underlying sandstone beds of the Upper Horseshoe Canyon Formation, and the surficial glacial drift.

45. **RRTAC 87-13: An Agricultural Capability Rating System for Reconstructed Soils. T.M. Macyk. 27 pp. $5.00**

This report provides the rationale and a system for assessing the agricultural capability of reconstructed soils. Data on the properties of the soils used in this report are provided in RRTAC 86-2.

46. RRTAC 88-1: **A Proposed Evaluation System for Wildlife Habitat Reclamation in the Mountains and Foothills Biomes of Alberta: Proposed Methodology and Assessment Handbook. T.R. Eccles, R.E. Salter and J.E. Green. 101 pp. plus appendix. $10.00**

The report focuses on the development of guidelines and procedures for the assessment of reclaimed wildlife habitat in the Mountains and Foothills regions of Alberta. The technical section provides background documentation including a discussion of reclamation planning, a listing of reclamation habitats and associated key wildlife species, conditions required for development, recommended revegetation species, suitable reclamation techniques, a description of the recommended assessment techniques and a glossary of basic terminology. The assessment handbook section contains basic information necessary for evaluating wildlife habitat reclamation, including assessment scoresheets for 15 different reclamation habitats, standard methodologies for measuring habitat variables used as assessment criteria, and minimum requirements for certification. This handbook is intended as a field manual that could potentially be used by site operators and reclamation officers. The study was co-funded with The Coal Association of Canada.

47. RRTAC 88-2: **Plains Hydrology and Reclamation Project: Spoil Groundwater Chemistry and its Impacts on Surface Water. M.R. Trudell (Compiler). 135 pp. $10.00**

Two reports comprise this volume. The first "Chemistry of Groundwater in Mine Spoil, Central Alberta," describes the chemical make-up of spoil groundwater at four mines in the Plains of Alberta. It explains the nature and magnitude of changes in groundwater chemistry following mining and reclamation. The second report, "Impacts of Surface Mining on Chemical Quality of Streams in the Battle River Mining Area," describes the chemical quality of water in streams in the Battle River mining area, and the potential impact of groundwater discharge from surface mines on these streams.

48. RRTAC 88-3: **Revegetation of Oil Sands Tailings: Growth Improvement of Silver-berry and Buffalo-berry by Inoculation with Mycorrhizal Fungi and N_2-Fixing Bacteria. S. Visser and R.M. Danielson. 98 pp. $10.00**

The report provides results of a study: (1) To determine the mycorrhizal affinities of various actinorrhizal shrubs in the Fort McMurray, Alberta region; (2) To establish a basis for justifying symbiont inoculation of buffalo-berry and silver-berry; (3) To develop a growing regime for the greenhouse production of mycorrhizal, nodulated silver-berry and buffalo-berry; and, (4) To conduct a field trial on reconstructed soil on the Syncrude Canada Limited oil sands site to critically evaluate the growth performance of inoculated silver-berry and buffalo-berry as compared with their un-inoculated counterparts.

49. RRTAC 88-4: **Plains Hydrology and Reclamation Project: Investigation of the Settlement Behaviour of Mine Backfill. D.R. Pauls (compiler). 135 pp. $10.00**

This three part volume covers the laboratory assessment of the potential for subsidence in reclaimed landscapes. The first report in this volume, "Simulation of Mine Spoil Subsidence by Consolidation Tests," covers laboratory simulations of the subsidence process particularly as it is influenced by resaturation of mine spoil. The second report, "Water Sensitivity of Smectitic Overburden: Plains Region of Alberta," describes a series of laboratory tests to determine the behaviour of overburden materials when brought into contact with water. The report entitled "Classification System for Transitional Materials: Plains Region of Alberta," describes a lithological classification system developed to address the characteristics of the smectite rich, clayey transition materials that make up the overburden in the Plains of Alberta.

50. **RRTAC 88-5: Ectomycorrhizae of Jack Pine and Green Alder: Assessment of the Need for Inoculation, Development of Inoculation Techniques and Outplanting Trials on Oil Sand Tailings. R.M. Danielson and S. Visser. 177 pp. $10.00**

The overall objective of this research was to characterize the mycorrhizal status of Jack Pine and Green Alder which are prime candidates as reclamation species for oil sand tailings and to determine the potential benefits of mycorrhizae on plant performance. This entailed determining the symbiont status of container-grown nursery stock and the quantity and quality of inoculum in reconstructed soils, developing inoculation techniques and finally, performance testing in an actual reclamation setting.

51. **RRTAC 88-6: Reclamation Research Annual Report - 1987. Reclamation Research Technical Advisory Committee. 67 pp. No longer available.**

This annual report describes the expenditure of $500,000.00 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

52. **RRTAC 88-7: Baseline Growth Performance Levels and Assessment Procedure for Commercial Tree Species in Alberta's Mountains and Foothills. W.R. Dempster and Associates Ltd. 66 pp. $5.00**

Data on juvenile height development of lodgepole pine and white spruce from cut-over or burned sites in the Eastern Slopes of Alberta were used to define reasonable expectations of early growth performance as a basis for evaluating the success of reforestation following coal mining. Equations were developed predicting total seedling height and current annual height increment as a function of age and elevation. Procedures are described for applying the equations, with further adjustments for drainage class and aspect, to develop local growth performance against these expectations. The study was co-funded with The Coal Association of Canada.

53. **RRTAC 88-8: Alberta Forest Service Watershed Management Field and Laboratory Methods. A.M.K. Nip and R.A. Hursey. 4 Sections, various pagings. $10.00**

Disturbances such as coal mines in the Eastern Slopes of Alberta have the potential for affecting watershed quality during and following mining. The collection of hydrometric, water quality and hydrometeorologic information is a complex task. A variety of instruments and measurement methods are required to produce a record of hydrologic inputs and outputs for a watershed basin. There is a growing awareness and recognition that standardization of data acquisition methods is required to ensure data comparability, and to allow comparison of data analyses. The purpose of this manual is to assist those involved in the field of data acquisition by outlining methods, practices and instruments which are reliable and recognized by the International Organization for Standardization.

54. **RRTAC 88-9: Computer Analysis of the Factors Influencing Groundwater Flow and Mass Transport in a System Disturbed by Strip Mining. F.W. Schwartz and A.S. Crowe. 78 pp. No longer available.**

Work presented in this report demonstrates how a groundwater flow model can be used to study a variety of mining-related problems such as declining water levels in areas around the mine as a result of dewatering, and the development of high water tables in spoil once resaturation is complete. This report investigates the role of various hydrogeological parameters that influence the magnitude, timing, and extent of water level changes during and following mining at the regional scale. The modelling approach described here represents a major advance on existing work.

55. **RRTAC 88-10: Review of Literature Related to Clay Liners for Sump Disposal of Drilling Wastes. D.R. Pauls, S.R. Moran and T. Macyk. 61 pp. No longer available.**

The report reviews and analyses the effectiveness of geological containment of drilling waste in sumps. Of particular importance was the determination of changes in properties of clay materials as a result of contact with highly saline brines containing various organic chemicals.

56. **RRTAC 88-11: Highvale Soil Reconstruction Project: Five Year Summary. D.N. Graveland, T.A. Oddie, A.E. Osborne and L.A. Panek. 104 pp. $10.00**

This report provides details of a five year study to determine a suitable thickness of subsoil to replace over minespoil in the Highvale plains coal mine area to ensure return of agricultural capability. The study also examined the effect of slope and aspect on agricultural capability. This study was funded and managed with industry assistance.

57. **RRTAC 88-12: A Review of the International Literature on Mine Spoil Subsidence. J.D. Scott, G. Zinter, D.R. Pauls and M.B. Dusseault. 36 pp. $10.00**

The report reviews available engineering literature relative to subsidence of reclaimed mine spoil. The report covers methods for site investigation, field monitoring programs and lab programs, mechanisms of settlement, and remedial measures.

58. **RRTAC 89-1: Reclamation Research Annual Report - 1988. 74 pp. $5.00**

This annual report describes the expenditure of $280,000.00 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

59. **RRTAC 89-2: Proceedings of the Conference: Reclamation, A Global Perspective. D.G. Walker, C.B. Powter and M.W. Pole (Compilers). 2 Vols., 854 pp. No longer available.**

Over 250 delegates from all over the world attended this conference held in Calgary in August, 1989. The proceedings contains over 85 peer-reviewed papers under the following headings: A Global Perspective; Northern and High Altitude Reclamation; Fish & Wildlife and Rangeland Reclamation; Water; Herbaceous Revegetation; Woody Plant Revegetation and Succession; Industrial and Urban Sites; Problems and Solutions; Sodic and Saline Materials; Soils and Overburden; Acid Generating Materials; and, Mine Tailings.

60. **RRTAC 89-3: Efficiency of Activated Charcoal for Inactivation of Bromacil and Tebuthiuron Residues in Soil. M.P. Sharma. 38 pp. ISBN 0-7732-0878-X. $5.00**

Bromacil and Tebuthiuron were commonly used soil sterilants on well sites, battery sites and other industrial sites in Alberta where total vegetation control was desired. Activated charcoal was found to be effective in binding the sterilants in greenhouse trials. The influence of factors such as herbicide:charcoal concentration ratio, soil texture, organic matter content, soil moisture, and the time interval between charcoal incorporation and plant establishment were evaluated in the greenhouse.

61. **RRTAC 89-4: Manual of Plant Species Suitability for Reclamation in Alberta - 2nd Edition. Hardy BBT Limited. 436 pp. ISBN 0-7732-0882-8. $10.00.**

This is an updated version of RRTAC Report 80-5 which describes the characteristics of 43 grass, 14 forb and 34 shrub and tree species which make them suitable for reclamation in Alberta. The report has been updated in several important ways: a line drawing of each species has been added; the range maps for each species have been redrawn based on an ecosystem classification of the province; new information (to 1990) has been added, particularly in the sections on reclamation use; and the material has been reorganized to facilitate information retrieval. Of greatest interest is the performance chart that precedes each species and the combined performance charts for the grass, forb, and shrub/tree groups. These allow the reader to pick out at a glance species that may suit their particular needs. The report was produced with the assistance of a grant from the Recreation, Parks and Wildlife Foundation.

62. **RRTAC 89-5: Battle River Soil Reconstruction Project Five Year Summary. L.A. Leskiw. 188 pp. $10.00**

This report summarizes the results of a five year study to investigate methods required to return capability to land surface mined for coal in the Battle River area of central Alberta. Studies were conducted on: the amounts of subsoil required, the potential of gypsum and bottom ash to amend adverse soil properties, and the effects of slope angle and aspect. Forage and cereal crop growth was evaluated, as were changes in soil chemistry, density and moisture holding characteristics.

63. **RRTAC 89-6: Detailed Sampling, Characterization and Greenhouse Pot Trials Relative to Drilling Wastes in Alberta. T.M. Macyk, F.I. Nikiforuk, S.A. Abboud and Z.W. Widtman. 228 pp. $10.00**

This report summarizes a three-year study of the chemistry of freshwater gel, KCl, NaCl, DAP, and invert drilling wastes, both solids and liquids, from three regions in Alberta: Cold Lake, Eastern Slopes, and Peace River/Grande Prairie. A greenhouse study also examined the effects of adding various amounts of waste to soil on grass growth and soil chemistry. Methods for sampling drilling wastes are recommended.

64. **RRTAC 89-7: A User's Guide for the Prediction of Post-Mining Groundwater Chemistry from Overburden Characteristics. M.R. Trudell and D.C. Cheel. 55 pp. $5.00**

This report provides the detailed procedure and methodology that is required to produce a prediction of post-mining groundwater chemistry for plains coal mines, based on the soluble salt characteristics of overburden materials. The fundamental component of the prediction procedure is the geochemical model PHREEQE, developed by the U.S. Geological Survey, which is in the public domain and has been adapted for use on personal computers.

65. **RRTAC 90-1: Reclamation Research Annual Report - 1989. 62 pp. No longer available.**

This annual report describes the expenditure of $480,000.00 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

66. **RRTAC 90-2: Initial Selection for Salt Tolerance in Rocky Mountain Accessions of Slender Wheatgrass and Alpine Bluegrass. R. Hermesh, J. Woosaree, B.A. Darroch, S.N. Acharya and A. Smreciu. 40 pp. $5.00**

Selected lines of slender wheatgrass and alpine bluegrass collected from alpine and subalpine regions of Alberta as part of another native grass project were evaluated for their ability to emerge in a saline medium. Eleven slender wheatgrass and 72 alpine bluegrass lines had a higher percentage emergence than the Orbit Tall Wheatgrass control (a commonly available commercial grass). This means that as well as an ability to grow in high elevation areas, these lines may also be suitable for use in areas where saline soil conditions are present. Thus, their usefulness for reclamation has expanded.

67. **RRTAC 90-3: Natural Plant Invasion into Reclaimed Oil Sands Mine Sites. Hardy BBT Limited. 65 pp. $5.00**

Vegetation data from reclaimed sites on the Syncrude and Suncor oil sands mines have been summarized and related to site and factors and reclamation methods. Natural invasion into sites seeded to agronomic grasses and legumes was minimal even after 15 years. Invasion was slightly greater in sites seeded to native species, but was greatest on sites that were not seeded. Invasion was mostly from agronomic species and native forbs; native shrub and tree invasion was minimal.

68. RRTAC 90-4: **Physical and Hydrological Characteristics of Ponds in Reclaimed Upland Landscape Settings and their Impact on Agricultural Capability. S.R. Moran, T.M. Macyk, M.R. Trudell and M.E. Pigot, Alberta Research Council. 76 pp. $5.00**

The report details the results and conclusions from studying a pond in a reclaimed upland site in Vesta Mine. The pond formed as a result of two factors: (1) a berm which channelled meltwater into a series of subsidence depressions, forming a closed basin; and (2) low hydraulic conductivity in the lower subsoil and upper spoil as a result of compaction during placement and grading which did not allow for rapid drainage of ponded water. Ponds such as this in the reclaimed landscape can affect agricultural capability by: (1) reducing the amount of farmable land (however, the area covered by these ponds in this region is less than half of that found in unmined areas); and, (2) creating the conditions necessary for the progressive development of saline and potentially sodic soils in the area adjacent to the pond.

69. RRTAC 90-5: **Review of the Effects of Storage on Topsoil Quality. Thurber Consultants Ltd., Land Resources Network Ltd., and Norwest Soil Research Ltd. 116 pp. $10.00**

The international literature was reviewed to determine the potential effects of storage on topsoil quality. Conclusions from the review indicated that storage does not appear to have any severe and longterm effects on topsoil quality. Chemical changes may be rectified with the use of fertilizers or manure. Physical changes appear to be potentially less serious than changes in soil quality associated with the stripping and respreading operations. Soil biotic populations appear to revert to pre-disturbance levels of activity within acceptable timeframes. Broad, shallow storage piles that are seeded to acceptable grass and legume species are recommended; agrochemical use should be carefully controlled to ensure soil biota are not destroyed.

70. RRTAC 90-6: **Proceedings of the Industry/Government Three-Lift Soils Handling Workshop. Deloitte & Touche. 168 pp. $10.00**

This report documents the results of a two-day workshop on the issue of three-lift soils handling for pipelines. The workshop was organized and funded by RRTAC, the Canadian Petroleum Association and the Independent Petroleum Association of Canada. Day one focused on presentation of government and industry views on the criteria for three-lift, the rationale and field data in support of three- and two-lift procedures, and an examination of the various soil handling methods in use. During day two, five working groups discussed four issues: alternatives to three-lift; interim criteria and suggested revisions; research needs; definitions of terms. The results of the workshop are being used by a government/industry committee to revise soils handling criteria for pipelines.

71. RRTAC 90-7: **Reclamation of Disturbed Alpine Lands: A Literature Review. Hardy BBT Limited. 209 pp. $10.00**

This review covers current information from North American sources on measures needed to reclaim alpine disturbances. The review provides information on pertinent Acts and regulations with respect to development and environmental protection of alpine areas. It also discusses: alpine environmental conditions; current disturbances to alpine areas; reclamation planning; site and surface preparation; revegetation; and, fertilization. The report also provides a list of research and information needs for alpine reclamation in Alberta.

72. RRTAC 90-8: **Plains Hydrology and Reclamation Project: Summary Report. S.R. Moran, M.R. Trudell, T.M. Macyk and D.B. Cheel. 105 pp. $10.00**

This report summarizes a 10-year study on the interactions of groundwater, soils and geology as they affect successful reclamation of surface coal mines in the plains of Alberta. The report covers: Characterization of the Battle River and Wabamun study areas; Properties of reclaimed materials and landscapes; Impacts of mining and reclamation on post-mining land use; and, Implications for reclamation practice and regulation. This project has led to the publication of 18 RRTAC reports and 22 papers in conference proceedings and referred journals.

73. **RRTAC 90-9: Literature Review on the Disposal of Drilling Waste Solids. Monenco Consultants Limited. 83 pp. $5.00**

This report reviews the literature on, and government and industry experience with, burial of drilling waste solids in an Alberta context. The review covers current regulations in Alberta, other provinces, various states in the US and other countries. Definitions of various types of burial are provided, as well as brief summaries of other possible disposal methods. Environmental concerns with the various options are presented as well as limited information on costs and monitoring of burial sites. The main conclusion of the work is that burial is still a viable option for some waste types but that each site and waste type must be evaluated on its own merits.

74. **RRTAC 90-10: Potential Contamination of Shallow Aquifers by Surface Mining of Coal. M.R. Trudell, S.R. Moran and T.M. Macyk. 75 pp. $5.00**

This report presents the results of a field investigation of the movement of salinized groundwater from a mined and reclaimed coal mine near Forestburg into an adjacent unmined area. The movement is considered to be an unusual occurrence resulting from a combination of a hydraulic head that is higher in the mined area than in the adjacent coal aquifer, and the presence of a thin surficial sand aquifer adjacent to the mine. The high hydraulic head results from deep ponds in the reclaimed landscape that recharge the base of the spoil.

75. **RRTAC 91-1: Reclamation Research Annual Report - 1990. Reclamation Research Technical Advisory Committee. 69 pp. No longer available.**

This annual report describes the expenditure of $499 612 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program. The report lists the 70 research reports published under the program.

76. **RRTAC 91-2: Winter Soil Evaluation and Mapping for Regulated Pipelines. A.G. Twardy. 43 pp. ISBN 0-7732-0874-7. $5.00**

Where possible, summer soil evaluations are preferred for pipelines. However, when winter soil evaluations must be done, this report lays out the constraints and requirements for obtaining the best possible information. Specific recommendations include: restricting evaluations to the time of day with the best light conditions; use of core- or auger-equipped drill-trucks; increased frequency of site inspections and soil analyses; and, hiring a well-qualified pedologist. The province's soils are divided into four classes, based on their difficulty of evaluation in winter: slight (most soils); moderate; high; and, severe (salt-affected soils in the Brown and Dark Brown Soil Zones).

77. **RRTAC 91-3: A User Guide to Pit and Quarry Reclamation in Alberta. J.E. Green, T.D. Van Egmond, C. Wylie, I. Jones, L. Knapik and L.R. Paterson. 151 pp. ISBN 0-7732-0876-3. $10.00**

Sand and gravel pits or quarries are usually reclaimed to the original land use, especially if that was better quality agricultural or forested land. However, there are times when alternative land uses are possible. This report outlines some of the alternate land uses for reclaimed sand and gravel pits or quarries, including: agriculture, forestry, wildlife habitat, fish habitat, recreation, and residential and industrial use. The report provides a general introduction to the industry and to the reclamation process, and then outlines some of the factors to consider in selecting a land use and the methods for reclamation. The report is not a detailed guide to reclamation; it is intended to help an operator determine if a land use would be suitable and to guide him or her to other sources of information.

78. **RRTAC 91-4: Soil Physical Properties in Reclamation. M.A. Naeth, D.J. White, D.S. Chanasyk, T.M. Macyk, C.B. Powter and D.J. Thacker. 204 pp. ISBN 0-7732-0880-1. $10.00**

This report provides information from the literature and Alberta sources on a variety of soil physical properties that can be measured on reclaimed sites. Each property is explained, measurement methods, problems, level of accuracy and common soil values are presented, and methods of dealing with the property (prevention, alleviation) are discussed. The report also contains the results of a workshop held to discuss soil physical properties and the state-of-the-art in Alberta.

79. **RRTAC 92-1: Reclamation of Sterilant Affected Sites: A Review of the Issue in Alberta. M. Cotton and M.P. Sharma. 64 pp. ISBN 0-7732-0884-4. $5.00**

This report assesses the extent of sterilant use on oil and gas leases in Alberta, identifies some of the concerns related to reclamation of sterilant affected sites and the common methods for reclaiming these sites, and outlines the methods for sampling and analyzing soils from sterilant affected sites. The report also provides an outline of a research program to address issues raised by government and industry staff.

80. **RRTAC 92-2: Reclamation Research Annual Report - 1991. Reclamation Research Technical Advisory Committee. 55 pp. ISBN 0-7732-0888-7. No longer available.**

This report describes the expenditure of $485,065 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the five program areas, and describes the projects funded under each program. It also lists the 75 research reports that have been published to date.

81. **RRTAC 92-3: Proceedings of the Industry/Government Pipeline Reclamation Success Measurement Workshop. R.J. Mahnic and J.A. Toogood. 62 pp. ISBN 0-7732-0886-0. $5.00.**

This report presents the results of a workshop to identify the soil and vegetation parameters that should be used to assess reclamation success on pipelines in Alberta. Six soil parameters (topsoil admixing; topsoil replacement thickness; compaction; soil loss by erosion; texture; and salinity) and six vegetation parameters (plant density; species composition; ground cover; vigour; weeds/undesirable species; and rooting characteristics) were selected as most important. Working groups discussed these parameters and presented suggested methods for assessing them in the field.

82. **RRTAC 92-4: Oil Sands Soil Reconstruction Project Five Year Summary. HBT AGRA Limited. 109 pp. ISBN 0-7732-0875-5. $10.00**

This report documents a five year study of the effects of clay and peat amendments to oil sand tailings sand on survival and growth of trees and shrubs. Ten species (jack pine, white spruce, serviceberry, silverberry, buffaloberry, pin cherry, prickly/woods rose, Northwest poplar, green alder, and Bebb willow) were planted into tailings sand amended with three levels of peat and three levels of clay. The treatments were incorporated to a depth of 20 cm or 40 cm. Data are provided on plant survival and growth, root size and distribution, disease and small mammal damage, herbaceous cover, soil moisture, soil chemistry, and bulk density.

83. **RRTAC 92-5: A Computer Program to Simulate Groundwater Flow and Contaminant Transport in the Vicinity of Active and Reclaimed Strip Mines: A User's Guide. A.S. Crowe and F.W. Schwartz, SIMCO Groundwater Research Ltd. 104 pp. plus appendix. ISBN 0-7732-0877-1. NOTE: This report is only available from the Alberta Research Council as ARC Information Series 119. $20.00**

The manual describes a computer program that was developed to study the influence of coal strip mining on groundwater flow systems and to simulate the transport of generated contaminants, both spatially and in time, in the vicinity of a mine. All three phases of a strip mine can be simulated: the pre-mining regional groundwater flow system; the mining and reclamation phase; and, the post-mining water level readjustment phase. The model is sufficiently general to enable the user to specify virtually any type of geological conditions, mining scenario, and boundary conditions.

N.L.C./B.N.C.
3 3286 50149 2975

ISBN 0-7732-0879-8

Printed on Recycled Paper ♻